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Bodo´s Power Systems®

Electronics in Motion and Conversion

June 2014

Always first-class results: Power Devices from Mitsubishi Electric

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powerguru.org

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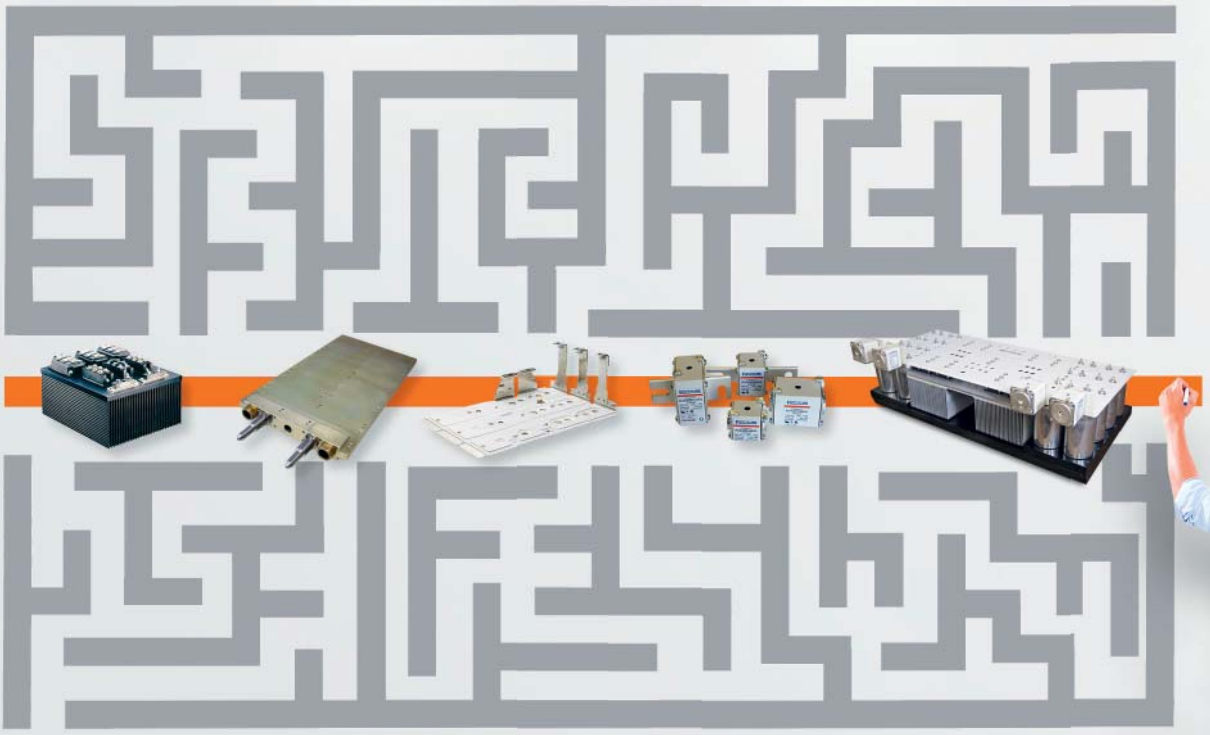

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It is Beach Time!

It is summertime in the northern hemisphere - my wife has already been swimming in the Baltic Sea. For me it is still a little too cold, 10°C (50F) rather than 20°C. As we can walk down to the beach from our home, we will soon be building sand castles with my Grandson. He is nearing 5 years old and is discovering the world.

There have been great conferences and shows in the first half of the year, and more are coming in the fall. This year electronica is again in Munich in November and a week later we are back to Nuremberg for sps ipc drives. EPE ECCE in Lappeenranta, Finland, will take place in late August and ECCE in North America will be in Pittsburg, PA, in September. And there others – all events with strong power related subjects that deserve attention. Just watch the event listings on my web-page and e-news-letter, and here in the magazine next to my View point.

This year my publication will mark its 100th issue. A great team works together to make this happen. Today, I want to thank Marisa for having contributed over the last few years as my corresponding editor focusing on events in Munich and around Southern Europe. By now Marisa has taken over a leading function for a German magazine, so her time is limited and we will not see her continuing with articles in my magazine. We all wish the best for her future activities.

The better news for me is that Alfred Vollmer has now agreed to contribute to the magazine. Welcome Alfred!
Alfred's first action has been writing the Guest Editorial in this issue, and he will continue to contribute on a regularly basis.

Communication is the only way to progress. We delivered twelve issues last year, each month, on time, every time. This year, the June issue marks 75 technical articles published, amongst 440 pages. They are all archived and retrievable at PowerGuru. As a media partner, Bodo's Power Systems serves readers across the globe. If you speak the language, or just want to have a look, don't miss our Chinese version: www.bodospowerchina.com.

My Green Power Tip for June:
Pick local strawberries from the field before they get packed and transported. Eat them right away – never more fresh. They are most enjoyable direct from the bush – eat them all, no transportation energy lost !

See you soon at EPE, ECCE, and around the world.
Best Regards

Events

Sensor + Test 2014,
Nuremberg, Germany, June 2-5
http://www.sensor-test.com/press

Intersolar 2014,
Munich, Germany, June 2-6 http://www.intersolar.de/de/intersolar-europe.html

PCIM Asia 2014,
Schanghai, China, June 17-19
http://www.mesago.de/en/PCC/home.htm

Utility Energy Storage Europe,
London, UK June, 18-19
http://www.smi-online.co.uk/utility/uk/conference/distributed-energy-storage

CWIEME 2014,
Berlin, Germany, June 24-26
www.coilwindingexpo.com/berlin/

Thermal Management 2014,
Denver CO, August, 6-7
http://www.thermalnews.com/conferences/

EPE ECCE 2014,
Lappeenranta, Finland, August 26-28 http://www.epe2014.com/

ECCE 2014,
Pittsburg, PA, September 15-18
http://www.ieee.org/conferences_events/conferences/conferencedetails/index.html?Conf_ID=21325

INNOTRANS 2014, Berlin, Germany, September 23-26 http://www.innotrans.de/

EU PVSEC 2014,
Amsterdam, Netherlands, Sept. 22-25
http://www.photovoltaic-conference.com/

INTELEC 2014, Vencouver, Canada, Sept.28- Oct. 2 http://www.intelec.org/

EDPC 2014,
Nuremberg, Germany, Sept. 30-Oct.1
http://www.mesago.de/de/EDPC/

LED professional, Bregenz, Austria, Sep. 30- Oct. 2 http://www.lps2014.com

ENERGY UNDER CONTROL

HO - A Range of Choices

A breakthrough in the tradeoff between performance, cost, size & mounting versatility. Whatever current you need to measure, mounting constraints or performance required, the HO current transducer range offers you the perfect solution.
6 families cover nominal currents from 2.67 A to 250 A, PCB-through-hole, surface-mount or multiple panel mounting versions, and offer an aperture or integrated primary conductor.
LEM ASIC technology brings Open Loop transducer performance closer to Closed Loop transducers, providing you with better control and increasing the efficiency of your system, but at a significantly lower price.

- Single +5V or +3.3V power supply
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- Half the offset and gain drifts of previous generation
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- Over-drivable reference voltage
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- Versatile panel mounting version (3 ways)
- -40 to +105°C operation

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Knowledge Transfer Partnership with Nottingham University

Power Electronic Measurements (PEM UK Ltd) has recently entered into a partnership with the University of Nottingham to develop new technologies and innovative ideas through the universities 'Knowledge Transfer Partnership' or KTP and as a result is now offering two post graduate/doctoral engineer positions.

KTP is a long-standing programme, funded in part by the Technology Strategy Board, that uses the knowledge and technology of universities to help successful SME businesses to improve their competitiveness, productivity and performance.

The KTP will involve working with world leaders in wideband Rogowski technology, PEM, and the internationally renowned Power Electronics, Machines and Controls Group at the University of Nottingham.

Two post graduate/doctoral engineer positions are available.

Applications for these research posts, can be found on the University of Nottingham's recruitment pages. Note registration is required to access the site.

https://jobs.nottingham.ac.uk/VM/Applications.aspx?jobId=1000

https://jobs.nottingham.ac.uk/VM/Applications.aspx?jobId=998

Please direct all enquiries directly to the university.

For further information on the KTP programme, please visit the University of Nottingham's website:

http://www.nottingham.ac.uk/news/pressreleases/2014/march/university-helps-six-businesses-take-a-technology-leap-through-12m-funding.aspx

www.pemuk.com

Julian Styles elected to Board of Power Electronics Industry Collaborative in USA

GaN Systems, a leading developer of gallium nitride power switching semiconductors, has announced that Julian Styles, Director of Business Development USA, has been elected to the Board of the Power Electronics Industry Collaborative (PEIC), the US industry consortium of suppliers, OEMS, stakeholders and research companies committed to accelerating development and growth of power electronics in the US. PEIC's aim is to increase investment in manufacturing capabilities and advance innovation in power electronics in the US as energy efficiency becomes ever more important globally.

"We are thrilled that GaN Systems has joined PEIC's Board of Directors," said PEIC Board President, Mark Bellinger. "Julian's expertise is extremely valuable and he will certainly be a great addition to the Board."

GaN Systems has developed a range of gallium nitride power switching products based on its proprietary Island Technology®. The company's devices overcome the limitations of traditional silicon semiconductors, offering far greater efficiency in power conversion applications such as solar, wind, smart-grid, electric and hybrid vehicles and power supply applications. GaN Systems has recently announced its products will be widely commercially available this year.

Styles comments: "Innovative semiconductor companies like GaN Systems succeed best when they are part of a thriving power electronics ecosystem. We are very impressed with PEIC's efforts to build and strengthen this ecosystem in the USA, and are delighted to be able to get involved."

www.gansystems.com

www.peic-us.org

Total Safety for PV Solar Systems and Absolute Protection of People

Mersen, a global expert in electrical safety systems, has developed the HelioProtection© range of dedicated products for the PV market, with an innovative safety solution for residential, commercial and industrial PV solar installations called Greeneye – Greenbrain®.

This PV safety system has an individual, remotely controlled shutdown feature per PV module, safeguarding against potential electrocution hazards. If there is a need for urgent shutdown, the Greeneye - Greenbrain® system immediately brings the output current and voltage of the individual PV modules to zero. The PV installation therefore becomes fully disconnected and safe for maintenance or construction work, or even in the case of fire, avoiding any risk of electrocution for personnel or firefighters.

Greeneye - Greenbrain® is a cost effective, fully plug & play system. It requires no specific wiring, since the shutdown command is transmitted by broadband over the PV array's DC wiring for enhanced safety.

Greeneye® is an electronic safety switch embedded in the junction box to shut down the PV modules. It is also available as an add-on box to retrofit all classic modules. It guarantees total safety until the installation is returned to service. It can also be used to create smart modules in the form of an electronic board that can be integrated into junction boxes on modules, or can be purchased directly in a module box produced in collaboration with the company Hüber+Sühner (RADOX® Blue Safety).

Greenbrain® is the ON / OFF activation module for the Greeneye® and controls the safety signal light. The shutdown feature can be remotely controlled either manually by hitting the emergency stop button or automatically by a DC arc detector or any other safety system to shut down the PV array. The system is failsafe and designed according to the IEC 61508 SIL2 safety standard for electronics.

To optimize operation and maintenance of the PV solar system, individual monitoring of strings and modules is also available as an option, compatible with Modbus, Ethernet or Wifi to interface with different monitoring systems.

Greeneye - Greenbrain® meets all the requirements of PV safety legislation in force on 1 January 2014: For the USA, the 2014 edition of the NEC, article 690.12; In France, the 2013 edition of UTE guidelines C 15-712-1; In Germany, the 2013 edition of VDE-AR-2100-712 guidelines and in Austria, the 2013 edition of OVE R 11-1

www.ep.mersen.com

Vincotech
The Power to Move Ahead

Speed and Flexibility

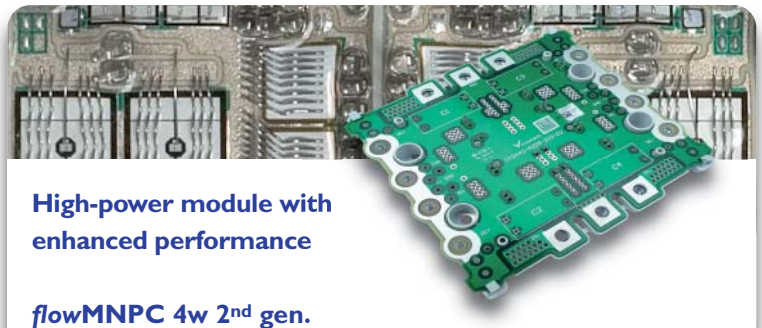
Vincotech, a 100% independent company within **Mitsubishi Electric Corporation**, is a market leader in power modules. With over 40 years of experience Vincotech develops and manufactures high-quality electronic power components for Motion Control, Renewable Energy, and Power Supply applications.

What Vincotech offers:

- Power modules with various topologies ranging from 4 A to 800 A and from 600 V to 2400 V
- Designed with low stray inductance (Rectifier, Sixpack, PIM (CIB), IPM, Boost, NPC, H-Bridge, Half-Bridge, PFC, etc.)
- 21 different standard housings

The Vincotech difference:

- A large variety of standard products for qualified, reliable solutions
- Building blocks to design your product – flexible designs to meet your specific requirements
- Ultra-low inductance designs
- Phase-change material – no more thermal grease



High-power module with enhanced performance

***flow*MNPC 4w 2nd gen.**

- Optimized semiconductors current ratings for better efficiency
- Mitsubishi's latest 6.1 generation IGBTs
- 650 V class semiconductors in Mixed voltage NPC topology
- Low commutation inductance

More details: www.vincotech.com/flowMNPC_4w_2nd

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www.vincotech.com

Industrial Drives | Solar Inverters | UPS | Embedded Drives | Welding | Power Supplies

First Global Summit for Advanced Manufacturing

Alpha is pleased to be a Gold Level Sponsor for the first Global Summit for Advanced Manufacturing (GSAM). This unique event, created for manufacturers, by manufacturers, and of manufacturers, comes to San Francisco on July 9 and 10 (co-located with SEMICON West 2014), with industry tours on July 11. GSAM answers the call for a forum that explores practical solutions for today's most pressing manufacturing challenges, including the convergence of miniaturization, automation, integration, ruggedization, materials and processes, along with other special topics. GSAM will feature case study-based presentations, networking opportunities and one-on-one individual meeting sessions on how to leverage today's successfully developed and manufactured products to yield viable solutions for the emerging manufacturing leaders of tomorrow.

"Technology in the marketplace has advanced over the years to change the way we live. In today's world, mass implementation of these new technologies needs to accelerate in order to keep pace with society's demands," observed GSAM co-chair Dr. Gene Kim of Alpha, a division of Alent plc. "Yet, we've repeatedly seen technologies that held great promise fall short of market realization because the promise came with too many barriers – capital expenditure, global supply-chain, technological scale-up, regulations, market timing, infrastructure, and so on. The true manufacturing value-add offered by a technological advancement comes from its total cost-of-ownership benefit, but key decision makers have lacked a forum in which they could candidly and thoroughly discuss this assessment. GSAM was conceived to encourage these important discussions – real people discussing real manufacturing challenges in an environment that cultivates manufacturing innovation."

Mark your calendars for GSAM's inaugural summit, which will be held at the San Francisco Marriott Marquis starting July 9th. More information can be found at www.gsam.org or by following the organization on Twitter at@GSAdvMfg. GSAM-related tweets can be created, viewed, and shared using the hash tag #GSAM14.

www.alpha.alent.com

Comprehensive Action Program at the SENSOR+TEST

The SENSOR+TEST 2014 from the 3rd to the 5th of June in Nürnberg is more than just a trade fair: Besides the exhibition itself, the extensive action program offers visitors numerous other opportunities to get up to date on the state of the art in sensor, measuring, and testing technology at first hand.

www.sensor-test.com

Successfully Passcertification for Multistandard EV Fast Chargers

ABB announced that their Terra 23/53 range of fast chargers has successfully passed the new European certification process for DC fast chargers at Applus IDIADA, the independent certification house in Spain. The ABB multi-standard chargers are compliant with CHAdeMO 1.0, the CE standard and new industry guidelines for multi standard fast chargers.

The CHAdeMO 1.0 certification was carried out in March in Spain, immediately following the official inauguration of Applus IDIADA as the first independent certification house for fast charging in Europe. In parallel to the formal standards-certification by Idiada, the ABB chargers passed the individual vehicle verification testing with Japanese and European car manufacturers, including backward compatibility testing with CHAdeMO 0.9 vehicles. WW

An extensive certification and verification process is a fundamental requirement for fast charging in general and public fast charging in particular. CHAdeMO 1.0 and CCS functionality require several stricter standards to be met, for example, with respect to charger isolation and power quality. In multi standard chargers such requirements are especially important and therefore ABB's chargers are immediately designed according to the MOCCA (Multi Outlet Charger Configuration Agreement) specification, an new industry guideline under development which governs the seamless and safe integration of multiple standards for fast charging into one single fast charger. This will ensure safety, technical architecture, functionality and usability to work in harmony when combining multiple outlets into one fast charger.

http://www.abb.com/evcharging

Joining Electronic Industry Citizenship Coalition

FCI Asia Pte Ltd, the global headquarters of a leading supplier of connectors and interconnect systems, announces the formal acceptance by Electronic Industry Citizenship Coalition (EICC) as an applicant member. FCI is proud to be part of a leading supply chain comprising of global electronic brands as with its customers and suppliers with a common objective to improve social and environmental practices in the electronics industries.

FCI continuously strives to ensure its businesses are conducted with highest ethical standards, taking into account its code of business conduct, applicable laws and regulation of the respective countries, and with the active integration of social and environmental practices throughout its supply chain.

Following its enrolment with EICC, FCI strengthens its commitment to further improve operations and offer assistance to existing and potential suppliers to adhere and support EICC's vision and mission.

www.fci.com

CWIEME Returns to Berlin for the 18th Year Running

CWIEME Berlin, the world's largest and most comprehensive event in the coil winding, insulation and electrical manufacturing industry, returns this summer with a greater and more engaging offer to visitors.

On the 24-25th June over 7,000 engineers, designers, buyers and academics from around the world will descend on the Messe Berlin in Germany for CWIEME Berlin 2014 – the largest annual meeting place for the global coil winding, insulation and electrical manufacturing community.

The three-day event, held in Germany's buzzing capital, will feature some 750 suppliers from over 40 countries – including top names ABB, Alstom, Euro Tanciatura, Hidria, Voestalpine and Von Roll – displaying the latest coils, electric motors, electromagnetic insulation materials, transformers and repairs solutions.

Now in its 18th year, CWIEME Berlin 2014 is set to be bigger and better than ever before, not least because of the wide range of products on show.

"CWIEME Berlin is not just an opportunity to source new products and suppliers, but to network, keep an eye on the competition – and learn about all the latest trends and technical advances," says Chloe Theobald, content manager for CWIEME Berlin. "We have a fantastic seminar programme lined up for our guests this year, covering a wide range of topics across the three days."

Learn something new

At CWIEME Central, the main seminar hub, visitors will benefit from technical presentations and panel discussions on topics such as:

- revenues, regulation and market opportunities for the LV and MV motor industries.
- wireless power transfer and inductive charging design for increased e-mobility.
- advances in OIP bushings for improved safety in HVDC equipment.
- REACH and the 'Greening' of technology debate.
- climatic resilience and risk mitigation for off-shore wind transformers.
- breakthroughs in nanoscience discoveries of new magnetic materials.

Speakers will include top industry experts:

- Professor Ivan Schuller, Director of the Center for Advanced Nanoscience (CAN) at the University of California-San Diego
- Paulo Cardano, Senior Expert OIP Bushings, Alstom Grid
- Professor Martin Doppelbauer from the Karlsruhe Institute of Technology
- Dr. Rolf Winter, Managing Director (Electrical Winding & Insulation Systems Division) at ZVEI
- Dr Faical Turki, Head of R & D, Paul Vahle GmBH

Meanwhile, CWIEME Berlin's Machinery Trail will provide regular live product presentations and machinery demonstrations across a wide variety of exhibitor stands, allowing visitors to see the latest technology in action. To register for your free visitor's entry pass visit:

www.coilwindingexpo.com/berlin

Thermal Management 2014, August 6-7, 2014 in Denver, CO

Advancements in Thermal Management 2014 is a symposium highlighting the latest advancements in thermal technology for product design, electronics, system development and process management. It will be held August 6-7, 2014 in Denver, Colorado.

This event features presentations on advancements in thermal management and technology for electronics packaging, temperature sensing and control, thermal materials, systems design and optimizing thermal properties. Topics will include all types of new thermal technology, commercial applications of recent advancements in thermal science, thermal research and development, and the latest market trends in thermal materials, products and systems.

www.thermalnews.com/conferences/

Full Member of the Wireless Power Consortium

Würth Elektronik eiSos has already been a member of the Wireless Power Consortium (WPC) for two years. The company has now upgraded its membership to become a full member.

The WPC is behind the development and maintenance of the QI standard, a standardised protocol for wireless power transfer. The consortium brings together 210 technology companies from all over the world to work on a pioneering charging technology. The QI standard has become the most successful wireless power standard on the market.

Würth Elektronik eiSos is part of this innovative and global network, made up of manufacturers of components and user devices as well as network operators, and was one of the first component manufacturers to develop coils both for transmitters and for receivers. Full membership will help the company consolidate its leadership in the field of inductive component solutions for wireless power transfer and it hopes to be able to strengthen its position still further. The company's objective is also to continue developing Qi compliant solutions.

Würth Elektronik eiSos already supplies a wide range of Qi standard transmitter and receiver coils.

For Würth Elektronik eiSos, wireless power transfer is one of the future trends in the electronics industry. "Our aim is to position ourselves in the wireless power market, which has strong growth potential, so that we can develop our lead over the competition," said Opitz.

www.we-online.com

APEC 2015 Call for Papers Open

APEC 2015 continues the long-standing tradition of addressing issues of immediate and long-term interest to the practicing power electronic engineer. For more information visit our website or view the full Call for Papers. Deadline for digest submission is July 7, 2014

Notification that a submission was accepted or declined will be emailed no later than October 6, 2014.

Final submission and registration will be accepted no later than November 17, 2014. At APEC 2015, the technical sessions will be given on March 17 - 19, 2015

Upload your submission online at no later than Monday, July 7, 2014 to:

http://www.epapers.org/apec2015

Reap the Fruits of its Development of 300 Millimeter Technology

Infineon is beginning to reap the fruits of 300-millimeter thin-wafer technology for power semiconductors, enabling it to achieve growth with a substantially lower level of capital employed compared with 200-millimeter wafers. The level of investments required to increase manufacturing capacities for power semiconductors in order to achieve the targeted growth rate is therefore decreasing.

Infineon is also in the early stages of a growth curve for products manufactured using standard-CMOS-based technologies with 65-nanometer and lower process structures. Unlike with power semiconductors, these technologies do not entail any major differentiating features from a manufacturing perspective and, as a result, Infineon intends to outsource the relevant production volumes to contract manufacturers, thus obviating the need in future to invest in in-house facilities to process these wafers.

The Company intends to allocate a greater share of backend manufacturing to subcontractors for those package types that offer no meaningful differentiation. Similarly, unlike in-house production, this will not involve any investment.

Great strides have been made over the course of the 2014 fiscal year to date to improve both current and future productivity by means of a whole raft of measures implemented in conjunction with a dedicated productivity improvement program. This enables higher production volumes for a given amount of capital investment.

www.infineon.com

Amantys and Avago Technologies Extend Collaboration in Power Electronics

Amantys has announced the successful implementation of its Amantys Power Insight communications protocol over Avago's (NASDAQ: AVGO) 50MBd Versatile Link transmitters and receivers.

Avago, the leading supplier of industrial fibre optic solutions, is working with Amantys to bring improved system information to its customers. As part of this cooperation Avago will develop a Versatile Link solution that benefits from the Amantys Power Insight capability.

Commenting on the announcement, Amantys CEO Erwin Wolf said: "This announcement endorses our strategy to develop solutions for intelligent control to power electronics systems. Our customers widely use Avago fibre optics in their systems so this development is of significant benefit to both companies."

Martin Weigert, Vice President and General Manager for Industrial Fibre Products at Avago, added, "We are delighted with the rapid progress we've made since Avago engaged with Amantys last year and this announcement marks the first results of our partnership."

The development of Insight is being driven to bring more intelligence into the power switching process. Armed with information harvested from the heart of the power switching system via Insight developers have the exciting prospect of being able to make use of it in their control plane to adapt their system during operation to achieve improved performance, availability and product life.

Amantys Power Insight provides several important capabilities including:

Monitoring of key system parameters at the IGBT switch during system operation

Reporting back detailed fault codes which help the system operator understand the nature of problems in the switch

www.amantys.com

From Imagination... to Real-time

Leading developer of open real-time digital simulators and hardware-in-the-loop testing equipment for electrical, electro-mechanical and power electronic systems

OPAL-RT's core software, RT-LAB, enables users to rapidly develop models suitable for real-time Simulation. OPAL-RT develops mathematical solvers and models specialized for accurate simulation of power electronic systems and electrical grids. They are integrated with advanced field programmable gate array (FPGA) I/O and processing boards to form complete solutions for RCP and HIL testing. OPAL-RT software along with validation and test benches are used by engineers and researchers at leading manufacturers, utilities, universities and research centres around the world.

www.opal-rt.com

OPAL-RT TECHNOLOGIES

ChiP-based Bus Converter Moduls Provide Breakthrough Power Density of 2750 W/in^3, Supplying up to 1.75 kW with 98% Peak Efficiency

Vicor Corporation (NASDAQ: VICR) announced the newest entries in its portfolio of isolated bus converter modules (BCMs®) based on the company's award-winning Converter housed in Package (ChiP) power component platform. Supplying up to 1.75 kW at 50 V with 98% peak efficiency and power density of 2750 W/in3, Vicor's new ChiP BCM fixed-ratio power converters deliver 5X the power density of competing solutions, further extending the company's power performance leadership in this product category.

Vicor has also introduced new digital telemetry and control capabilities for its ChiP BCM portfolio, available as an option for the new 1.75 kW modules and previously announced 1.2 kW modules. This PMBus™ compliant digital interface option gives system designers access to the ChiP BCM's internal controller, enabling digital communication with an array of ChiP BCMs via a single bus for control, configuration, monitoring and other telemetry functions.

Vicor's ChiP BCMs' power performance profile is made possible by the underlying ZCS/ZVS Sine Amplitude Converter™ topology. Operating at megahertz switching frequency, ChiP BCMs enable fast response time and low noise operation at industry leading efficiencies. High fixed frequency operation also simplifies and reduces the size of external filter designs, yielding additional cost savings and accelerating time to market.

The new ETSI and ITU compliant 1.75 kW modules support a nominal input voltage of 400 V and nominal output voltage of 50 V, with a K-factor of 1/8. Vicor's 1.2 kW and new 1.75 kW BCMs are offered in the 6123 package. Standard BCM features include bidirectional operation, under-over-voltage lockout, over-current, short circuit and over-temperature protection.

"With the introduction of our newest ChiP BCMs, we've again raised the bar for bus converter power density while introducing new digital communication functionality for customers seeking flexible control and monitoring capabilities," said Stephen Oliver, VP of VI Chip product line, Vicor. "These features extend the value and versatility of the ChiP BCM product family, enabling power engineers to achieve new levels of system power performance for high voltage DC distribution in datacenter, telecom and industrial applications."

Converter housed in Package (ChiP) Platform

Vicor's ChiP platform sets best-in-class standards for a new generation of scalable power modules. Leveraging advanced magnetic structures integrated within high density interconnect (HDI) substrates with power semiconductors and control ASICs, ChiP-based power modules provide superior thermal management supporting unprecedented power density. Thermally adept ChiP-based modules enable customers to achieve low cost power systems with previously unattainable system size, weight and efficiency attributes, quickly and predictably. The ChiP platform embodies a modular power system design methodology that enables designers to achieve high-performance, cost-effective power systems from AC or DC sources to the Point of Load using proven building blocks.

Pricing and Availability

Vicor's 1.75 kW ChiP BCMs and 1.2 kW ChiP BCMs are available today – pricing for OEM quantities is $170.00 and $120.00 respectively. The digital telemetry and control options are priced separately. Visit the website for more information. To order, email custserv@vicorpower.com or call 00 800 8426 7000.

About Vicor Corporation

Headquartered in Andover, Massachusetts, Vicor Corporation designs, manufactures and markets innovative, high-performance modular power components, from bricks to semiconductor-centric solutions, to enable customers to efficiently convert and manage power from the wall plug to the point of load. Complementing an extensive portfolio of patented innovations in power conversion and power distribution with significant application development expertise, Vicor offers comprehensive product lines addressing a broad range of power conversion and management requirements across all power distribution architectures, including CPA, DPA, IBA, FPA™ and CBA. Vicor focuses on solutions for performance-critical applications in the following markets: enterprise and high performance computing, telecommunications and network infrastructure, industrial equipment and automation, vehicles and transportation and aerospace and defense electronics.

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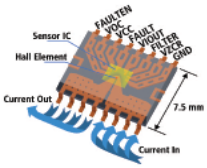
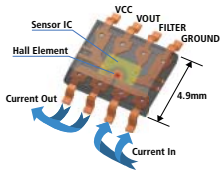
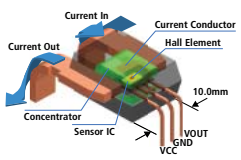
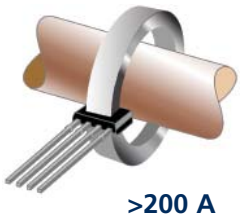


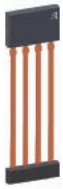
5 to 40 A





50 to 200 A





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Key Applications

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- Hybrid electric vehicle power systems

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Tomorrow's Power Engineers

By Alfred Vollmer, corresponding editor, Bodo´s Power systems

Being an electrical engineer, I still have a lot of interest in technological details even though I have been working as a components-focused technical journalist now for more than 25 years. During my numerous conversations with engineers and managers in the industrial and automotive environment, I realized that we need to actively encourage pupils/students to become engineers. I think we must unleash a storm of enthusiasm for engineering already at a quite early stage, in the middle of puberty, when the young people tend to go to their room in order to relax and read.

Therefore, I decided to team up with two other journalists (Ingolf Seifert and Dr. Henry Wojcik) in order to encourage the young people to start an engineering career. How do we do this? We start in their daily lives and tell them about the inner life of their daily companions like smartphones, tablet PCs etc. However, we do not do this on an academic level, we write it in a way that they can catch up with and we illustrate it with individually designed 3D graphics, animations and videos. You can get a glimpse at it by looking at http://www.mikrochip-abc.com/so-funktioniert-ein-transistor.html even though this is a very early illustration, which is still in German.

Ingolf and Henry already wrote a book (in German) about how a chip is made, the so-called Nanoscout, which was donated to high schools in the Silicon Saxony area around Dresden/Germany, and they received excellent feedback. My part is to contribute to the chapters about applications of semiconductors in automotive, industrial, traction, windpower etc.

May be electrical vehicles (EVs) will be a very attractive means of transporting information about how an inverter (in both directions) works and how important power semiconductors are for smooth and safe operation of the car. The goal is to describe lively how the system works without ever talking about di/dt or dφ/dt and (almost) without any diagrams. As the traction system is more than just the inverter this chapter will enable me to write about heat sinks, cooling, electromagnetic compatibility and a few other fascinating aspects of the power semiconductor world.

Even though my heart beats intensively for analog and power solutions the EV also needs control, which will allow me to write about microcontrollers, memories and other digital components as well. However, this example will clearly show that even the best digital circuits will not be able to drive high loads – neither in cars nor in trains nor in industrial applications.

This new book named Mikrochip ABC is scheduled to be available in German by the end of this year and is supervised by several supporting companies (just check out the company logos at microchip-abc.com, but the list is still open) including the ZVEI, the German electronics industry association. Like the Nanoscout the book will be given free of charge to German high schools determined by the supporting companies. Once pupils/students will read the German book, we will start creating an English version because we already have several requests from all over Europe.

So if you have any ideas about how to very simply describe technical aspects at pupils/students level that you'd like to share you may happily mail ideas, drafts and other inputs to me at:

mikrochip-abc@avollmer.com. And, of course, if your marketing guys consider this project to be interesting they can also contact me.

Finally yet importantly, I would like to emphasize an angle that is unfortunately quite often neglected. When it comes to engineering, we tend to forget addressing 50 % of the potential future engineers. As we cannot afford to neglect 50 % of the potential future workforce, we must address both female and male future engineers.

Here is the project contact for Alfred Vollmer: mikrochip-abc@avollmer.com

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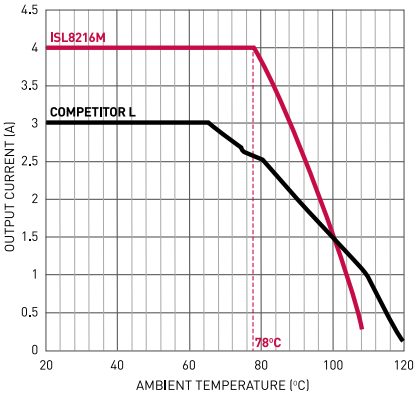

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Electronics Industry Digest

By Aubrey Dunford, Europartners

SEMICONDUCTORS

For 10 years, sensors and actuators have been the semiconductor industry's fastest growing market segment. However, in 2013, this normally vibrant category showed nearly no sales increase in the year, so IC Insights. The sensors/actuators market was flattened last year by slow unit growth and price erosion in its two largest sensor product categories—accelerometers/gyroscopes and magnetic-field sensors—as well as ongoing weakness in actuators. Inventory corrections in some cellphone

segments, falling average selling prices, and delays of purchases by cautious system makers caused the sensors/actuators business to stall out in 2013 with total revenues increasing just 0.3 percent to slightly more than $ 8.7 billion, but a new wave of stronger growth is expected to begin in 2014. Worldwide sales of sensors and actuators are forecast to grow 14 percent to a new all-time high of $ 9.9 billion in 2014, followed by a 16 percent increase in 2015 to $ 11.4 billion.

Worldwide semiconductor capital equipment spending totaled $ 33.8 billion in 2013, an 11.5 percent decline from 2012, so Gartner. Wafer-level manufacturing equipment demand performed above the market with strength in lithography and associated processes, while back-end manufacturing segments fared significantly worse than average. The top five vendors command nearly 57 percent of the total market, up 5 points from the prior year. Applied Materials held onto the No. 1 spot based on its relative strength in deposition and etch. Relative strength in lithography helped ASML to retain the No. 2 position. Lam Research moved into the No. 3 spot due to its strong performance in etch and deposition. TEL was impacted by the significant decline in the yen-to-dollar exchange rate, as well as an unfavorable customer buying pattern.

PASSIVE COMPONENTS

Germany's PCB market posted a 4.4 percent growth in February compared to the same period last year, so the Zvei. Cumulative growth for the first two months of the year went up by 5.6 percent from last year. Order intake rose by 20.2 percent YoY--the second highest order intake rate for the past 30 months (next to January's 32.4 percent YoY growth). Book-to-Bill ratio meanwhile reached 1.13.
The number of employees grew by 2.4 percent.

OTHER COMPONENTS

Advanced Energy Industries (AEIS), a US-based supplier of power and control technologies for high-growth, thinfilm manufacturing and solar-power generation, has acquired HiTek Power Group, a privately-held provider of high voltage power solutions. Based in the United Kingdom and founded in 1972, HiTek offers a comprehensive portfolio of high voltage and custom built power conversion products ranging from 100V to 500kV designed to meet the demanding requirements of OEMs worldwide. These products target applications including semiconductor wafer processing and metrology, scientific instrumentation, mass spectrometry, industrial printing, and analytical x-ray systems.

EMS PROVIDERS

Manufacturing Market Insider, a newsletter specializing in the electronics manufacturing services industry, has released its annual MMI Top 50 list of the world's largest EMS providers. In 2013, Top 50 sales reached a new high of $ 254.3 billion. Top 50 sales grew by 1.9 percent last year, not surprising given less-than-expected growth in world markets and caution among OEMs. To qualify for the 2013 list, EMS providers needed a minimum of $ 239 M in sales, compared with the prior year's cutoff of $ 210 M. In order, the top ten were Hon Hai, Pegatron, Flextronics, Jabil, New Kinpo Group, Sanmina, Celestica, Benchmark Electronics, Shenzhen Kaifa Technology and Universal Scientific Industrial. A top-ten ranking required $ 2.30 billion in revenue, up from $ 2.11 billion in 2012. The Top 50 list includes 11 Europeans : Zollner Elektronik Group --Germany (13), Asteelflash --France (19), Enics -- Switzerland (24), éolane--France (25), Videoton Holding --Hungary (28), Neways Electronics International --The Netherlands (35), PartnerTech --Sweden (38), Kitron --Norway (40), Selcom Elettronica --Italy (43), Scanfil EMS --Finland (47), Lacroix Electronics --France (49).

Neways Electronics has signed a letter of intent to acquire BuS Group, a German EMS provider headquartered in Riesa. BuS Group has a total staff of approximately 900, including 50 developers and records annualized sales of around € 106 M. The intended acquisition fits Neways' strategy and significantly strengthens its footprint in the German EMS market. BuS Group consists of two operating companies in Germany (Riesa and Erfurt) and one operating company in the Czech Republic (Decin). BuS Group's customers are mainly found in the automotive industry but also in industrial electronics, medical technology, railway and air traffic. Neways has operating companies in the Netherlands, Germany, Slovakia and China, with a total of around 1,909 employees in 2013. In 2013, Neways booked net turnover of € 265.0 M.

DISTRIBUTION

TE Connectivity, a world leader in connectivity, announced a strategic engagement with TTI Europe, the specialist distributor of passive, connector, electromechanical and discrete components. The engagement is part of the TE Industrial business unit strategy to provide customers with improved service levels, while extending the geographic reach of its products. As a result of the engagement, TE's Industrial business unit will achieve greater coverage and focus in the EMEA market, with customers now able to leverage TTI's broad and deep stock and design-in support of TE Industrial products. Additionally, customers will benefit from extensive pre-provisioned inventory with low Minimum Order Quantity (MOQ) conditions on select product programs.

This is the comprehensive power related extract from the «Electronics Industry Digest», the successor of The Lennox Report. For a full subscription of the report contact:
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or by fax 44/1494 563503.

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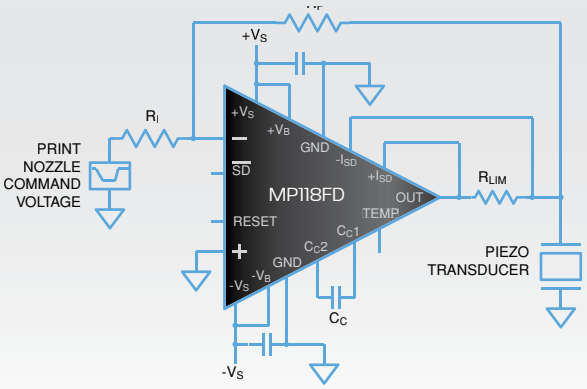
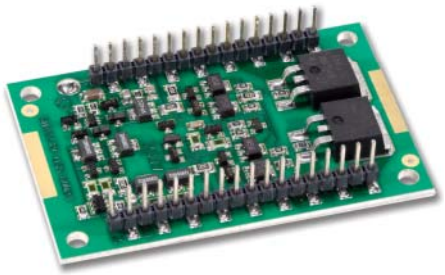
Shut Down!

Power Amplifier Self Protects With Over Current Shut Down

THE NEW MP118FD IS ALSO THERMALLY EFFICIENT BY DECREASING QUIESCENT POWER DISSIPATION – A LOW 26mA

The MP118FD power operational amplifier is a next generation product design targeting industrial piezo drive applications. This open frame design integrates several new layers of onboard circuit protection safe guards. In addition to temperature shut down and external shut down, the device provides a new twist that replaces the more common over current limit functionality with the ability to completely shut down its output drivers when put into an over current situation. This will protect the power amplifier from over stress due to excessive current and unsafe power dissipation. Onboard temperature monitoring circuitry, also new, enables the MP118FD to shut down the system before any permanent damage can occur. The MP118FD is compatible with supplies up to 200V and is capable of 10A of continuous output current, or 12A PEAK.





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Darnell Energy Summit will Feature Smart Materials

By Richard Ruiz, Research Analyst

With over 50 companies and organizations represented on the combined Advisory Committee, momentum is rapidly building for the second-annual Darnell's Energy Summit (DES '14) to be hosted in Richmond, Virginia, 23-25 September. DES '14 will be a combined event featuring the Eleventh Darnell Power Forum (DPF '14) plus the Sixth Green Building Power Forum (GBPF '14) plus the Fifth Smart Grid Electronics Forum (SGEF '14). DES '14 will feature the next-generation power electronic devices, architectures and systems. A key focus of DES '14 will be broad and growing impact of Smart Materials on energy efficiency and power conversion.

Smart materials include numerous leading-edge technologies such as MEMS, piezoelectrics, thermoelectrics, advanced semiconductor materials such as GaN, SiC and GaAs, new magnetic materials, and so on. They will find application in all areas of power conversion and energy management including; power converters, energy harvesting, energy storage, sensors, power switching, wireless power transfer, thermal management, actuators/controls, and more. DES '14 will include the most in-depth discussion ever of these new Smart Materials and their impact on power conversion and energy management.

"Groundbreaking research and development of smart materials has resulted in Virginia Commonwealth University (VCU) and Richmond being selected as the site for DES '14," stated Jeff Shepard, President of Darnell Group.

"This prestigious event is coming to Richmond entirely because of Virginia's global leadership in what are called 'high deformation' smart materials, which experts in the field believe hold a multi-billion dollar economic opportunity," stated VCU School of Engineering Dean Barbara D. Boyan, Ph.D.

Gary Tepper, Ph.D., Chair of VCU's Department of Mechanical and Nuclear Engineering, said: "Public and private entities in Virginia have spent more than 15 years developing these technologies. The organizers of the Energy Summit recognize these remarkable smart materials are ready to be used in hundreds of products and deserve the attention of the international power electronics industry."

VCU's Smart Materials Laboratory has been at the forefront of the research of high-deformation smart materials, which are wafers the size of a playing card or smaller that generate electricity when they are flexed or vibrated.

"At first, this technology was years ahead of the market – but now the market has caught up," said Karla Mossi, Ph.D., director of the Smart Materials Lab. "The opportunity is right in front of us. But, we must move quickly."

"High-deformation smart materials will revolutionize the way materials affect our everyday life," Mossi said. "These devices are more powerful, more rugged and they can be much less expensive than competitive technologies. These big advantages set this technology apart and, most importantly, can bridge the gap between research and the development of new products."

The materials can bring to reality a wide range of applications, including products that are self-powered and no longer need batteries, which means lower cost and less environmental waste, and also sensors and actuators with important medical applications, she noted.

According to Mossi, "NASA's Langley Research Center in Hampton was the original inventor of high deformation smart materials in the 1990s. The Face Companies of Norfolk have worked since then to make these materials commercially viable, and Virginia's Commonwealth Center for Advanced Manufacturing can play an important role in accelerating their adoption across multiple markets."

Robert Klenke, Ph.D., Chair of Electrical and Computer Engineering at VCU, said: "With the introduction of distributed, renewable energy sources, new demand profiles from such things as electric vehicles, the aging of the power grid, and the push towards energy conservation through demand management, advances in smart grids and associated technology are critically needed. The School of Engineering is developing new capabilities in these areas, including a microgrid installed by Dominion Voltage, Inc. in our Engineering West Building."

"We are excited about the opportunity to work with VCU to host DES '14," stated Jeff Shepard, President of Darnell Group. "The technologies available at VCU can find immediate practical applications in power conversion and energy management and range from thermal management, to energy harvesting, to actuators, and more. Add to that the depth of experience the VCU technical team has with microgrid operation in a real-world environment and it becomes obvious the breadth of technical content that will be brought to DES delegates as a result of this sponsorship."

Of course, GaN, SiC, GaAs and other advanced semiconductor materials are well-known as smart materials for next-generation power converters. Silicon MOSFETs, IGBTs, Schottkys, and other devices are under 'attack' by these advanced semiconductor devices. The DPF component at DES will include extensive discussion of new power semiconductor materials and devices.

Piezoelectric materials have been introduced that support multiple applications such as harvesting of mechanical energy and vibrations and the fabrication of powerful actuators that can open/close valves and perform other critical functions. And synthetic jets can be produced that provide high-velocity streams of air for spot cooling and other thermal management needs.

Synthetic jets based on smart materials could provide a thermal management breakthrough for next-generation systems. With a piezoelectric diaphragm driven up and down hundreds of times per second by an ac power source, a synthetic jet pulls in the surrounding air (or other fluid) into a chamber and then expels it.

When used with air as the working fluid, a synthetic jet can provide a highly-targeted and high-velocity flow of cooling air. Synthetic jets made using advanced piezoelectric composite materials can be very thin (fractions of an inch) and extremely rugged. Although the mechanism is fairly simple, extremely fast cycling can require high-level engineering to produce a device that will last in industrial applications.

Nonmagnetic transformers are another area of emerging smart materials technology. One example is the piezoelectric transformer (PT) called the Transoner. These electrical energy transmission devices are electromechanical, not electromagnetic. Transoners are useful in applications involving power conversion, power switching, and wide band signal processing.

MEMS devices have begun appearing for a diverse range of applications such as energy harvesting and power switching. For example, arc-free switching of hundreds of volts has been demonstrated using a MEMS switching device. The resulting arrays are able to conduct current more efficiently and can open orders of magnitude faster than traditional macroscopic mechanical relays. The prototype system has been used to turn on and off a 3/4-hp motor and, more importantly, to provide arc-less protection in a test simulating a 16,000A fault current. Applications envisioned for this highly-scalable technology range from mobile phone handsets to grid-connected appliances.

Thermoelectrics are finding broad application from the generation of milliWatts of power for sensor nodes to ever larger power systems, such as the Multi-Mission Radioisotope Thermoelectric Generator that provides over 100W of power to the Mars Curiosity rover. And Peltier cooling devices have been developed for a wide range of applications from precision cooling of solid-state lasers to spot cooling for LED lighting fixtures.

Separate calls for papers have been issued for each of the constituent events. Each of the individual events will maintain its unique identity and will continue to serve different groups of stakeholders. These co-located events will bring together thought leaders across the areas of advanced power electronics, energy management, micro grids, the smart gird, and related topics of global importance. DES '14 will leverage the successful track records of the separate events to create powerful opportunities for synergy.

DPF '14 will again be an exciting international event that focuses on "advanced power conversion technologies" needed for the successful development of next-generation power systems. There is tremendous synergy possible from discussions broadly focused on digital power, power management, energy efficiency, advanced components, energy storage, new power architectures, and more. DPF is a solutions-oriented event, with a strong emphasis on practical advances in power electronics. In addition to a strong focus on today's "best practices," DPF looks forward toward next-generation solutions and advances. http://energysummit.darnell.com/DPFcall.php

GBPF '14 will consider all aspects of building power including high-voltage and low-voltage dc distribution, hybrid ac and dc distribution architectures, and dc micro grids. A convergence of technologies is occurring that will change how buildings are powered. These technologies include the continued rapid growth of distributed generation (DG) resources; the emergence of high-efficiency lighting technologies; wireless building automation systems; demand-side management of building energy use by electric utilities; and more. http://energysummit.darnell.com/GBPcall.php

Control, Communications and Security will be three of the major themes of SGEF '14. The successful deployment of the smart grid will be dependent on numerous technology and standards developments for electronic equipment. For the smart grid to have benefits, it must be able to reliably communicate to the downstream loads and also be able to turn these loads on/off or turn them up/down as appropriate. http://energysummit.darnell.com/SGEcall.php

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Technical Characteristics of GaN and SiC

By Alex Lidow Ph.D.; Efficient Power Conversation

The Key Take Aways

- Gallium nitride (GaN) and silicon carbide (SiC) will displace silicon (Si) in power conversion due to higher performance and lower cost.
- GaN and SiC will service different segments of the market. GaN will take over consumer, telecom, and computer applications, while SiC will be most prominent in industrial applications that require higher voltages and current.
- Manufacturing costs of GaN and SiC will come down in the next three years. The cost of GaN devices is dominated by growing a thin layer of the crystal on top of a standard silicon wafer. The cost of SiC devices is dominated by growing the SiC crystal in a bulk ingot.

GaN and SiC both start with a large fundamental advantage over silicon in the power conversion market. The devices can be made much, much smaller in size for the same relative voltage and current handling capability. This reduction in size is due to the higher bonding energy of the atoms in the crystal – thus they are called wide band gap semiconductors. In the case of GaN, the crystals also have a higher mobility of electrons. The relative theoretical performance of these three crystals can be seen in figure 1, where the vertical axis shows the relative size of the device and the horizontal axis shows the device's ability to block voltage. As the voltage increases, so does the relative die size for Si, GaN or SiC. But, at all voltages SiC and GaN devices can be several orders of magnitude smaller than silicon!

On the market today there are GaN and SiC transistors that are 5-10 times superior to the theoretical limit of silicon, and with the anticipated technological progress, following a "Moore's Law" rate, much higher performance is expected from GaN and SiC over the next few years.

With superior performance, the remaining questions are: (a) what are the relative advantages and disadvantages of GaN and SiC, and (b) why haven't GaN and SiC devices already replaced Si?

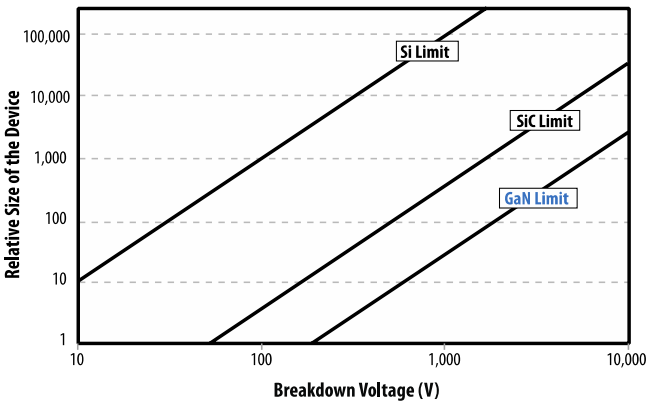


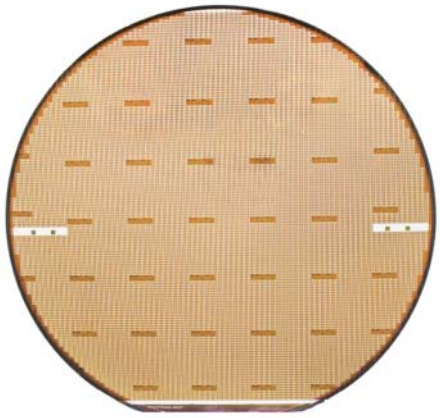
Figure 1: Relative theoretical performance of GaN, Si, and SiC transistors.

Relative Advantages: GaN vs. SiC

The initial successes of GaN and SiC over Si have been at opposite ends of the voltage spectrum. GaN has made inroads in applications requiring 600 V and below, while SiC has made inroads in applications requiring 1200 V and above. The reason for this split is two-fold: speed and cost.

GaN devices are not only smaller than Si power MOSFETs (the dominant type of silicon transistor at voltages below 600 V), but also much faster. The speed of GaN stems from (a) the size advantage – electrons do not have to travel as far in a smaller device, and (b) the higher mobility of electrons in a GaN crystal – electrons can move more quickly. Power conversion applications at voltages of 600 V and below become much more efficient when devices can switch faster. For this reason there is a premium market that forms the pool of "early adopters" for GaN transistors.

SiC transistors are finding success at higher voltages primarily due to their size advantage. Today, a very high voltage SiC device (1200 V or higher) can be an order of magnitude smaller than a Si IGBT, currently the dominant type of silicon transistor at these voltages. This size advantage makes a significant difference in industrial applications such as UPS systems, motor drives, and high voltage DC-DC transmission.



The advantage of GaN over SiC at lower voltages comes from the differences in the respective manufacturing technologies used today. The most cost effective way to manufacture a GaN transistor is to grow a thin epitaxial layer of the crystal on top of a silicon wafer. This wafer can then be processed into active transistors in a standard silicon CMOS foundry at a very low cost. Furthermore, low voltage GaN transistors do not require the expensive and bulky, and performance-degrading packages that are required for Si MOSFETs and SiC transistors. As a result, GaN transistors are extremely cost effective at lower voltages compared to both Si and SiC.

The advantage of SiC over GaN at higher voltages comes from the structure of the device. At high voltages, the transistor is more efficient when the current is conducted through the wafer. This type

of transistor is called a vertical device as compared with the low voltage GaN transistor, which is called a lateral device. The vertical structure necessitates that the entire SiC wafer be made of a single crystal type. SiC crystals are much lower cost than GaN crystals today and thus enjoy an early adoption lead in this market.

GaN (600 V and lower)

	2013	2016
Starting Material	lower	lower
Epi Growth	higher	same
Wafer Fab	lower	lower
Assembly	lower	lower
OVERALL	higher	lower

(a)

SiC (1200 V and higher)

	2013	2016
Starting Material	higher	same
Epi Growth	n/a	n/a
Wafer Fab	higher	same
Assembly	same	lower
OVERALL	higher	lower

(b)

Elements of Manufacturing Cost

A technologically superior device that costs more to manufacture will enjoy success in niche markets that require the enhanced performance. In order to completely displace a technology a product needs both higher performance AND lower cost. The key elements of cost in manufacturing a transistor are (1) the starting material, (2) growing the epitaxial crystal (low voltage GaN and Si only), (3) wafer fabrication, and (4) the cost of packaging. Table1 compares GaN costs with Si power MOSFETs on the left, and SiC costs with IGBTs on the right. The comparison looks three years ahead to illustrate the evolution of cost components expected over that time.

Both GaN and SiC enjoy the advantage of smaller device size compared with Si. In the case of GaN, this translates into an immediate advantage in the cost of starting materials, since the GaN transistor is grown on a standard silicon wafer. SiC, however, requires a relatively expensive substrate, even taking its size advantage into account. Over the next few years the cost improvements in SiC crystal growth are expected to neutralize the advantages of Si IGBTs giving SiC a relative cost advantage at 1200 V and higher.

Today, when comparing GaN transistors with MOSFETs, the epitaxial growth of GaN on the silicon wafer is the sole cost disadvantage. With advances in epitaxial growth equipment, however, this disadvantage is expected to equalize in the next few years, giving GaN a clear cost advantage over the aging MOSFET.

Displacement of Silicon in Power Conversion

With both performance and cost advantages over their silicon counterparts, GaN and SiC will displace Si in their respective segments of the $12B power transistor market in the not-too-distant future.

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Power Modules for Electric and Hybrid Vehicles

This article presents 2 new Mitsubishi Electric power module series for Electric Vehicle (EV) and Hybrid Electric Vehicle (HEV) power-train inverter and converter applications.
By Mikio Ishihara, Mitsubishi Electric Corp. Power Device Works, Fukuoka, Japan and Seiichiro Inokuchi, Marco Honsberg and Eckhard Thal Mitsubishi Electric Europe B.V., Ratingen, Germany

The J1-Series

First a new 6-in-1 IGBT module ("J1-series") with integrated water cooled Al-fin and Direct Lead Bond (DLB) structure is described [1]. Compared to conventional products, the adoption of these innovative technologies has led to an improved thermal performance of 30%, has reduced the cooling stack's footprint by 40% and its weight by 76%.

Introduction

The market for EV/HEV is growing by increasing global environment protection awareness. The power semiconductor module has become an important part to determine vehicle performance. Having pioneered the first mass production of dedicated automotive power semiconductor modules in 1997 already, the products of Mitsubishi Electric have been used in various mass-produced EV/HEV ever since.

The evolution of EV/HEV has been remarkable in this time frame and the power semiconductor module has become the key part for EV/HEV applications providing the required high performance, small size and light weight. In addition, a wide variety of EV and HEV covering various sizes and power requirements have been developed and power semiconductor modules were required with matching wide product line-up responding to these market requirements.

The J1-Series

Under these circumstances a family of new automotive power semiconductor modules "J1 Series" has been developed based on the concept of "high performance" and "compact size and light-weight" (Figure 1).

The J1 series modules are using a 6-in-1 topology (see Figure 2).

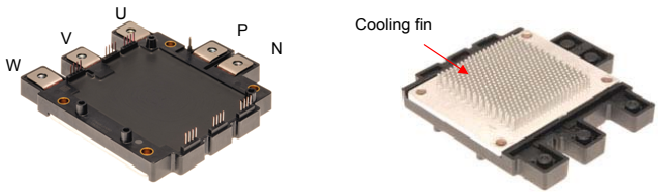

Figure 1: External appearance of the J1-Series Power Module

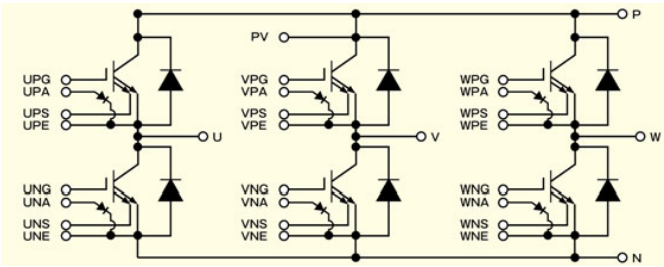

Figure 2: J1-Series circuit diagram

All IGBT-chips have integrated current sense emitters and integrated temperature sense diodes.

The module ratings and package dimensions are given in Table 1.

The excellent Vce(sat)-values are the result of using the latest CSTBT chip technology.

Type name	Ratings (Ic/Vces)	Vce(sat) Typ. @Ic, 25°C	Package Size (mm)
CT600CJ1A060	600A/650V	1.4V	120x115.2x31 (6-in-1)
CT400CJ1A090	400A/900V	1.7V	

Table 1: J1-Series Power Module Line-up

Package structure

J1-Series modules are employing a built-in Aluminium cooling-fin. A cross sectional drawing is shown in Figure 3.

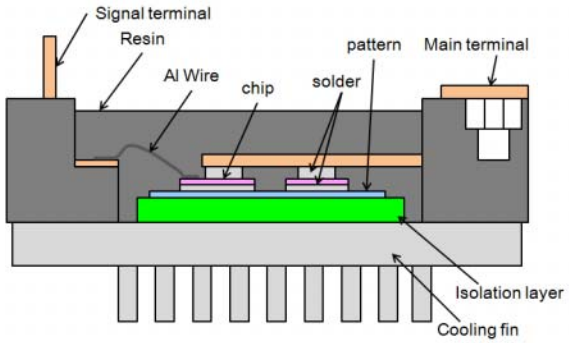

Figure 3: Internal structure of J1-Series

The directly water cooled module base plate allows to eliminate the thermal contact resistance between module base plate and external heat sink that is unavoidable for inverter designs with conventional modules. In this way a remarkable reduction of total Rth(j-w) compared to conventional designs is possible to achieve. For utilizing this benefit a reliable water cooling system must be designed for fitting the J1-module into the direct water cooling.

Direct Lead Bonding

The new J1-Series is using a highly reliable Direct Lead Bonding (DLB) structure [3] instead of conventional Al wire-bonding (W/B) technology. The principle difference between both technologies can be seen in Figure 4.

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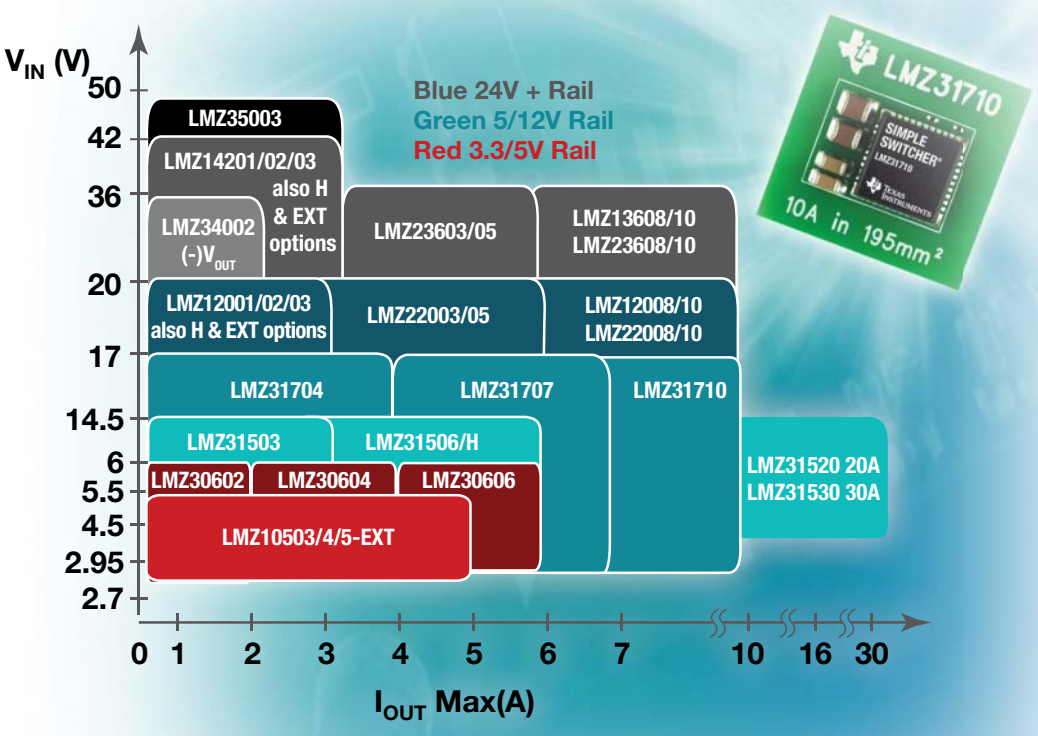

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The DLB structure provides increased chip surface contact area greatly improving the power module current carrying capability. Compared to W/B packages, by utilizing the DLB structure, the package's internal lead resistance and the parasitic internal package inductance can be reduced by more than 50% [4].

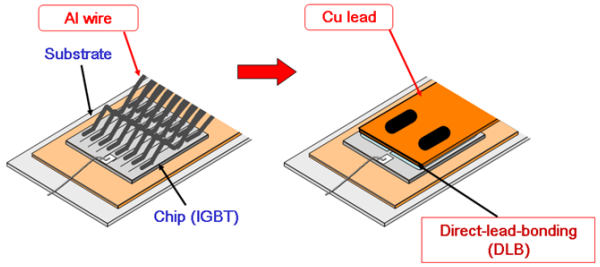

Figure 4: Conventional W/B vs. DLB structure

One further important advantage of the increased chip surface contact area is the uniform temperature distribution across the chip surface reducing the peak temperature value, and hence, resulting in lower stress for the emitter side chip contacting system. In other words, the DLB structure addresses the power-cycling stress issues usually encountered in conventional WB packages.

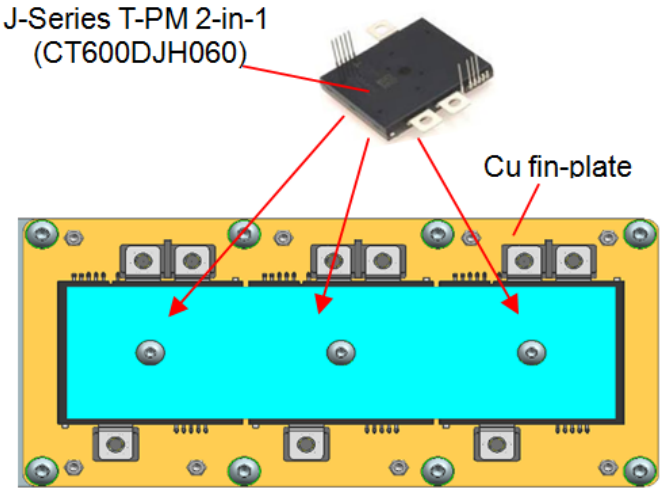

Figure 5: Cooling stack assembly with conventional 600A/650V J-TPM modules

Compact cooling stack design

In comparison with more conventionally packaged products (J-Series T-PM [2], see Figure 5), the new J1-Series reduces the footprint of a 3-phase cooling stack by 40% (Figure 6).

Despite the fact that aluminium cooling-fins have lower thermal conductivity compared to copper

cooling-fin structures, this selection provides several advantages to EV/HEV applications. Among these advantages the most prominent one is durability when Aluminium is exposed directly to coolants and its light weight. As shown in Figure 7 and 8, as much as 76% weight reduction and 30% thermal performance improvement was achieved when comparing 6-in-1 power module inverter solutions. The two solutions compared in Figure 7 are based on same module current and voltage ratings (600A/650V) for three-phase EV/HEV motor drives.

Evaluation Kit

Since the package size is not differing for several voltage and current classes, the test and evaluation of new J1-Series modules can be facilitated by a unique test environment that provides a DC-link capacitor, a simple and efficient cooling system (water jacket) and an interface circuitry with dedicated ICs controlling the state-of-the-art chip technology comprising an on-chip-diode for temperature sensing as well as the proven mirror emitter technology to detect over current situations before the IGBT de-saturates naturally.

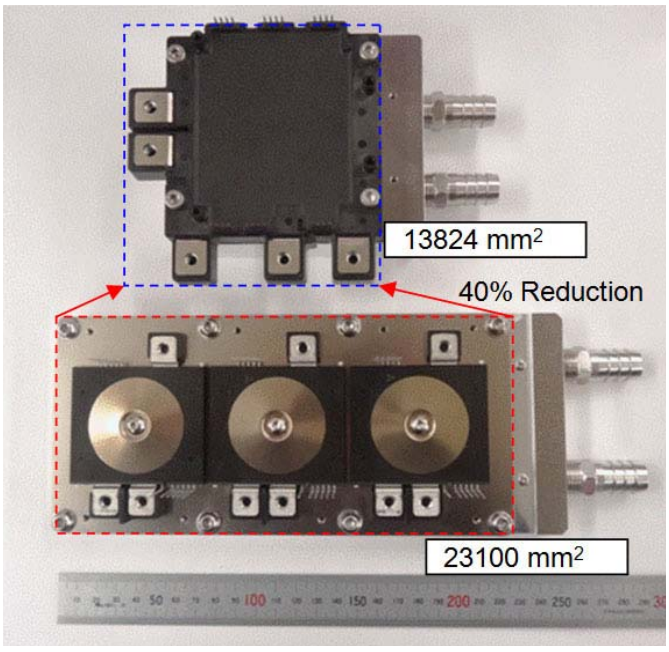

Figure 6: Cooling stack footprint of J1-Series and conventional J-TPM

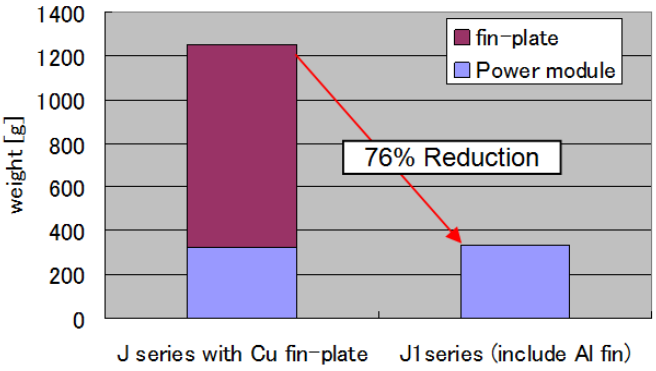

Figure 7: Cooling stack weight comparison

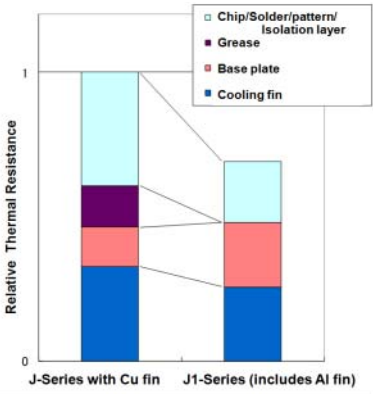

Figure 8: Thermal resistance Rth(j-w) comparison

The evaluation kit (gate drive board, DC-link capacitor, water jacket) is available for the evaluation of this new J1-Series IGBT module family (Figure 9 and 10). The comprised drive and protection circuit for short circuit (SC), over temperature (OT) and under voltage (UV) along with a switching mode power supply is optimized for the J1-Series. It is simply mounted on top of the J1-Series IGBT module and provides a comprehensive interface to a superimposed system control unit.

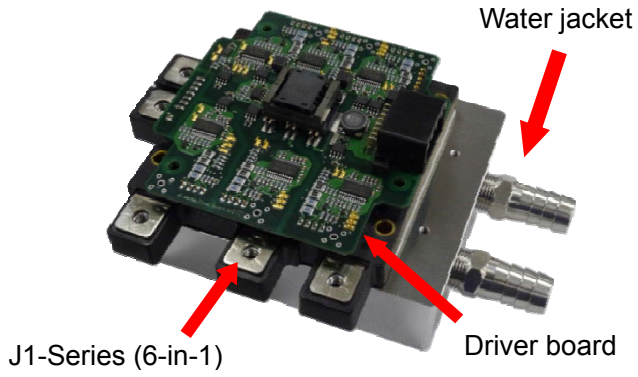

Figure 9: Water jacket and driver board

Figure 10: DC-link capacitor

Experimental results

The new J1-Series' power handling capability in conjunction with the performance of the thermal interface construction was experimentally verified under the following test conditions: main battery voltage = 350V; PWM switching frequency (fc) = 5kHz, 10kHz; coolant temperature (Tw) = 65°C; coolant flow-rate = 10 l/min. The proposed evaluation kit for J1-Series IGBT modules (Figure 9) has been used to carry out this investigation. Under these conditions the inverter output current can exceed 420Arms (corresponding to more than 80kW output power) at a maximum junction temperature of below 150°C as graphically presented in Figure 11.

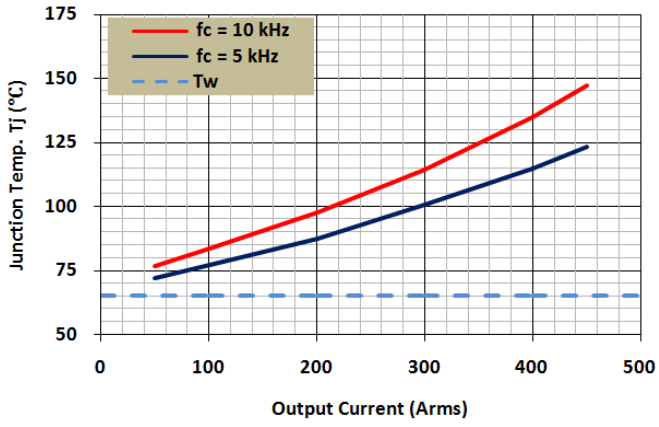

Figure 11: Experimental Inverter performance of a J1-Series Power Module (600A/650V) sample

J1-Series summary

A new series of automotive power semiconductor modules "J1-Series" has been developed to meet the requirements of the evolving EV/HEV market. The J1-Series achieves high performance, compact size and light weight and contributes to the evolution of automotive inverter system by providing state-of-the-art chip technology employing on chip temperature sensing and mirror Emitter current sensing technology paired with proven high reliability core packaging technologies like Direct Lead Bonding (DLB) and Aluminum cooling fin.

The J-Series IPM "+B"

The second part of this article presents the extension of Mitsubishi's 6-in-1 Intelligent Power Module Series for EV and HEV applications [2]. The newly developed "+B" J-IPM series is offering enhanced power ratings in a more compact package design, an integrated switching mode power supply (SMPS) and an improved thermal cycling capability. All dedicated functions for controlling IGBTs safely under EV/HEV application conditions (driving, protection and sensing) are integrated into the J-IPM.

Simplifying the testing of this new technology, an optimized evaluation kit comprising a water-cooling jacket and a driver board with dedicated drive and protection circuitry has been developed for this new family of automotive 6-in-1 IGBT modules.

Intelligent Power Modules (IPM) have been widely used in motor control applications in industry and in High Voltage (HV) traction applications. A dedicated series of IPMs ("J-Series IPM" [2]) has been designed for automotive applications for providing both high functionality and high reliability. The "J-Series IPM" lineup has been extended by 2 new modules, the so called "+B types" [2] with increased current handling capability. The target for this new development was to offer a "ready-to-use" solution to heavy electrical or heavy hybrid electrical vehicles designers. The "+B type" module ratings are given in Table 2.

Type name	Vces-rating	Ic-rating	Package Size (mm)
PM800CJG060G	650V	800A	165x144.2x32 (6-in-1)
PM500CJG120G	1200V	500A	

Table 2: J-Series Intelligent Power Modules "+B type"

Figure 12: J-Series IPM "+B" package outline

Both "+B" IPM types are configured as "6-in-1" and are using the package outline shown in Figure 12:

Integrated functions

The integrated functionality is given in the block diagram in Figure13. The power block consists of 6 freewheeling diodes and 6 IGBTs with integrated current sense emitters and temperature sense diodes. The protection block covers the following functions:

- IGBT chip over temperature protection
- Short circuit current protection
- Power supply under voltage protection
- DC-link voltage detection (optional)
- Analogue chip temperature detection circuit

The control block consists of the IGBT drivers and a fault output logic responsible for generating a single fault output signal Fo in case one of the protection functions had operated. The isolation block is using automotive grade high speed opto couplers for signal isolation. The power supply & I/O block contains a built-in switch mode power supply for feeding all IGBT drivers from a single +12V external power source as well as I/O processing circuits.

Input signals are: a) the PWM input from the Control MCU and b) the mandatory for automotive applications "ready" state monitoring signal.

Output signals are: a) the fault output signal Fo; b) the analogue chip temperature signal Tout and c) the analogue DC-link voltage signal VDC out (optional).

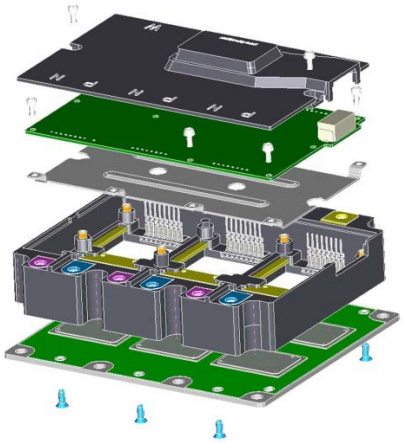

Figure 14: Three-Dimensional (3D) view of the "+B" IPM's construction

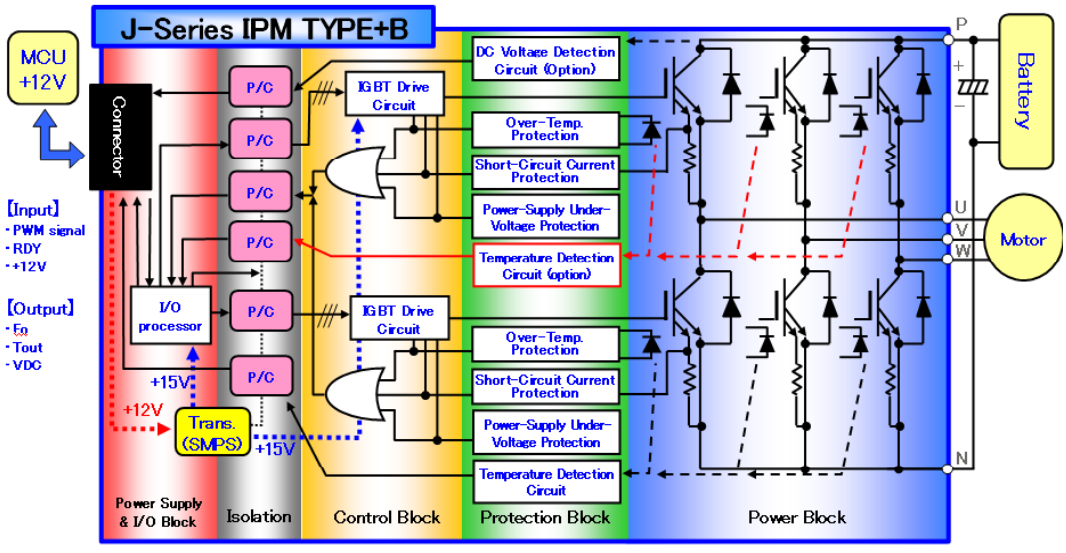

Figure 13: J-Series IPM type +B Block diagram

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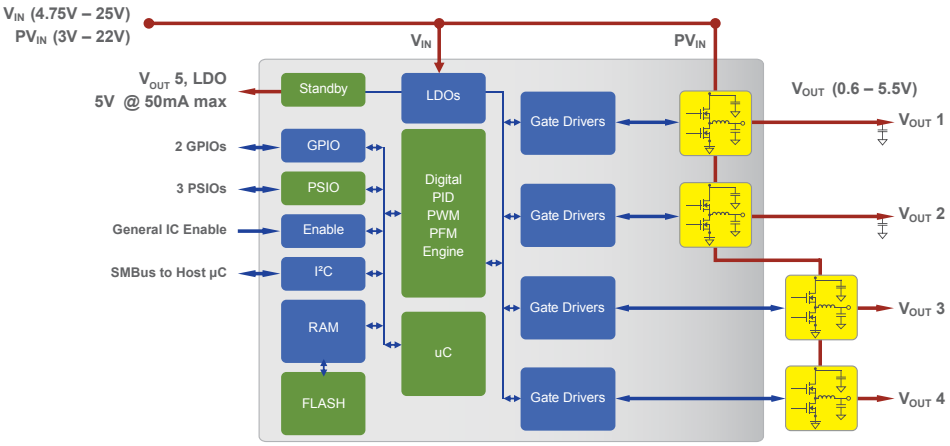

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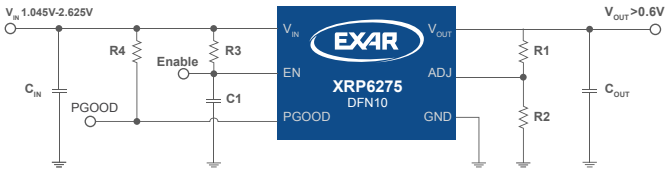

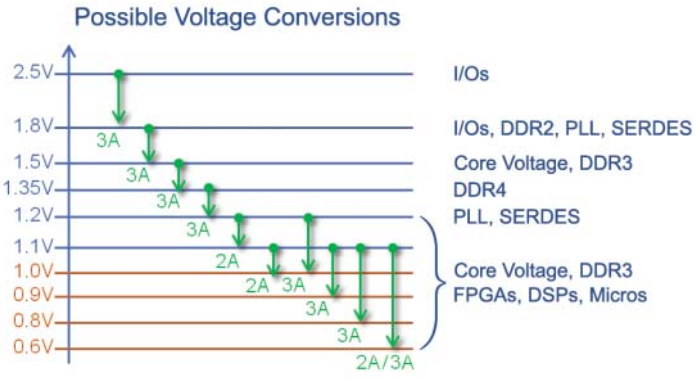

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Module structure and robustness against vibration

A 3D-view of the +B type IPM is shown in Figure 14. A shielding plate is inserted between the power part and control PCB to prevent IGBTs and FWDis radiated noise to interfere with the IPM's control board and disturb the overall control of the inverter.

Lead-free solder has been employed to comply with the "End of Life Vehicles" (ELV) directive.

For ensuring a reliable electrical connection to the superimposed control system a dedicated automotive grade connector has been used to facilitate the needed simplicity of assembly on one hand and robustness against vibration on the other hand. Furthermore, the entire IPM structure has been analytically modeled and simulated under vibration stress. The outcome of this investigation has influenced the outer and inner construction of the IPM resulting in robustness of the case and especially the sensitive control board against mechanical stress. Finally the mechanical ruggedness has been confirmed by actual vibration tests under the following conditions: acceleration > 10G, frequency = 100 ~ 1000Hz, direction = X, Y, and Z Axis.

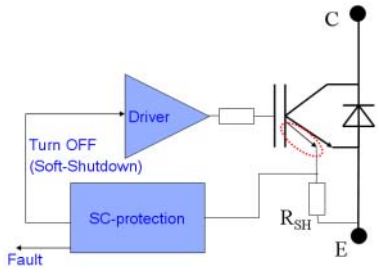

Figure 15: Short circuit protection circuit

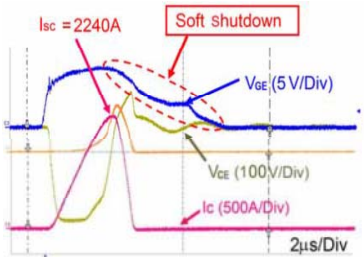

Figure 16: Short circuit turn-off waveforms PM-800CJG060G

Short circuit protection

One highlight of J-Series IPM is the over-current protection, employed by a fast response on-chip current sensor. This mirror Emitter sensing function shown in Figure 15 along with the soft shutdown approach provides a comparatively low current and voltage stress to the IGBT throughout the entire short circuit event that in turn provides a higher reliability than conventional de-saturation based detection methods. Figure 16 shows the typical short circuit turn-off behavior of a J-Series IPM.

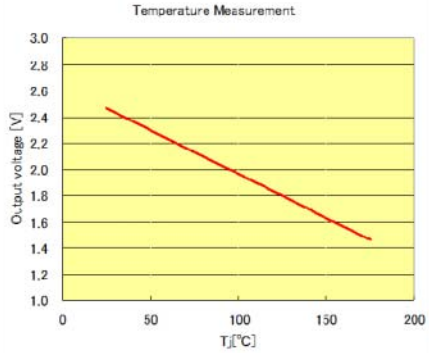

Figure 17: On-chip temperature measurement result: Vout vs. Tj

Enhanced input / output functions

The "RDY" input terminal acts as an added input fail-safe protection measure. In case of an error situation the superimposed control system can directly shut down the IPM by sending a corresponding logic signal to this terminal.

The employed IGBT temperature monitoring function provides an analogue output signal Tout indicating the IGBT chip actual surface temperature through the utilization of a built-in temperature sensor located at the center of the chip. Compared to conventional temperature monitoring with thermistors located on the base plate, this approach provides higher accuracy and a linear output over a wide temperature range as indicated in Figure 17.

The J-IPM type "+B" comprises a new function, e.g. a Tout output selection. This new feature selects automatically the hottest chip and routes the temperature information to the Tout terminal. Especially under locked rotor mode condition or at low output frequency operation at high load current the system control has the advantage to always look at the most stressed chip. This information, besides the efficient protection against chip over temperature, creates the possibility to adjust the inverter output power, the switching frequency or early warning messages and contributes to the reliability of the entire drive system.

The DC-link voltage monitoring function (optionally available) provides an analogue output signal (VDC out) indicating the voltage across the IPM's main P and N terminals, giving valuable information to battery management functions.

Reliability

The optimization of the base plate's and the substrate's match of linear expansion coefficients (CTEs) as well as the interconnection between chip and substrate and the bonding technology itself have a great impact on the module's reliability [5]. The J-Series IPM type "+B" employs a "low linear expansion coefficient" base plate resulting in a substantial improvement of the T/C capability by about 5–10 times to that of general industrial power modules.

In line with the high reliability targets of the mechanical construction the integrated control board has been verified specifically for automotive applications by dedicated high-temperature and high-humidity bias stress tests.

J-Series IPM "+B" summary

The new J-IPM "+B" modules provide a complete "easy-to-use" 6-in-1 system solution for high power HEV/EV applications. It allows building compact, robust and reliable propulsion systems for heavy electrical and heavy hybrid electrical vehicles. The use of J-IPM "+B" helps to reduce the propulsion system development time as the implemented IPM functionality is providing ready state-of-the-art answers to all needs of an automotive inverter design.

Literature

[1] M. Ishihara et al.: "New compact package Power Modules for Electric and Hybrid Vehicles (J1-Series)", PCIM 2014 conference proceedings
[2] S. Inokuchi et al.: "A new versatile Intelligent Power Module (IPM) for EV and HEV applications", PCIM 2014 conference proceedings
[3] T. Ueda, et al. ''Simple, Compact, Robust and High-performance Power module T-PM (Transfer-molded Power Module)'' ISPSD2010, pp. 47-50, 2010
[4] M. Ishihara, et al., "New Transfer-mold Power Module Series for Automotive Power-Train-Inverters", PCIM 2012, Proceedings, pp. 1408-1413.
[5] K. Hussein, et al., "IPMs Solving Major Reliability Issues in Automotive Applications", IEEE-ISPSD 2004, Proceedings, pp. 89-92.

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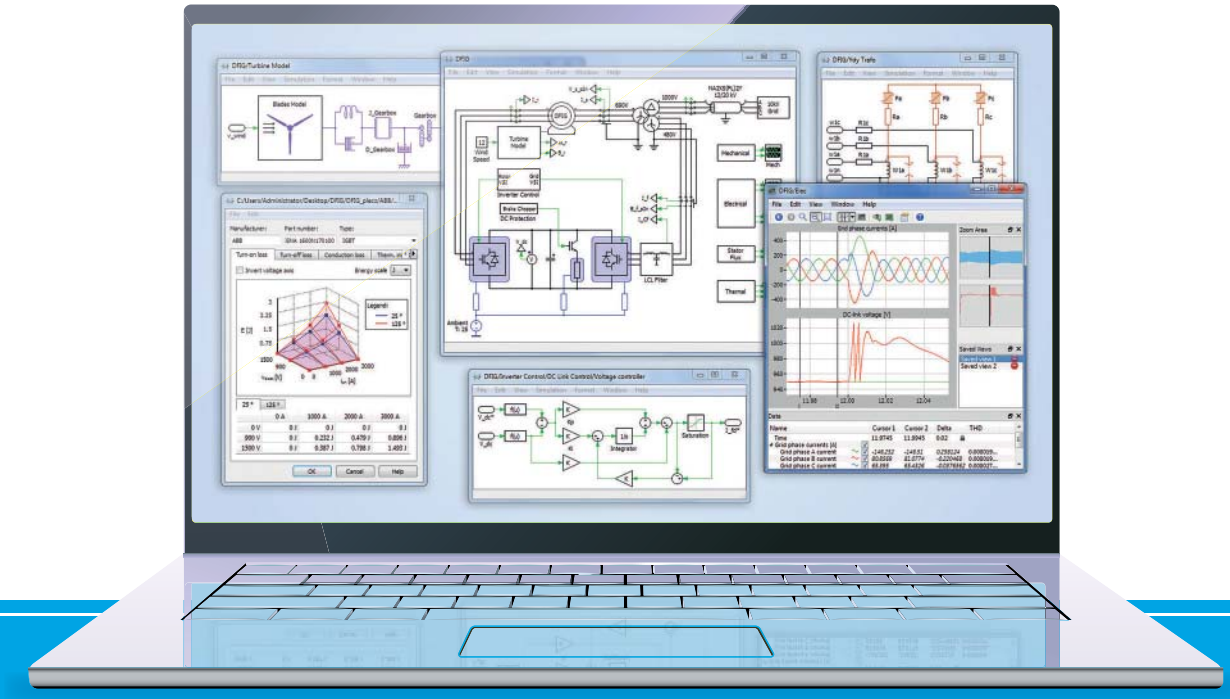

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In modern topologies the inductive components require most of the space and contribute significantly to the total weight and system costs. Therefore the biggest potential for achieving a compact and cost efficient system lies in the optimization of these devices. Most of the effort made in the last years was focused on the thermal management and using better soft-magnetic materials in order to reduce the volume.

By Stefan Herzog, Alexander Stadler and Christof Gulden,
STS Spezial-Transformatoren Stockach GmbH & Co. KG, Stockach, Germany

However, for a specific class of inductors there is a further opportunity for optimization. In topologies such as buck or boost and PFC SMPS the inductors are usually used in a unipolar way, i.e. the current flows only in one direction of the coil. In these chokes only half of the theoretically maximum swing of the flux density is realized. This article deals with the technique of biasing the core with a permanent magnet in order to reach the full swing. The result is a choke which is smaller, lighter and more economical compared to existing constructions.

Working principle

Biasing the soft-magnetic core with a permanent magnet is a principle which has been investigated for a long time [1, 2, 3]. Even more recent work deals with this tempting technology [4, 5, 6] . However, up to now no commercially available solution is known, where the biasing method is used in serial production.

The biasing technique concerns unipolar applications, for example storage or PFC inductors. The typical current characteristic of the first class is shown in figure 1.

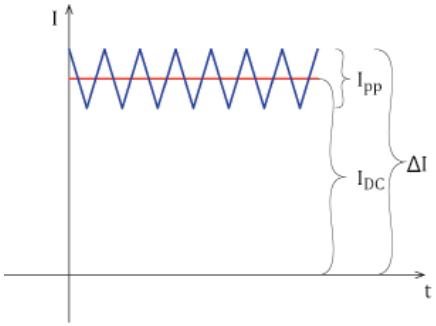

Figure 1: Current shape of a DC inductor

The basic idea is defined by the formula

$$L \cdot \Delta I = N \cdot \Delta B \cdot A_{fe} \qquad (1)$$

with the given inductance L and the current swing ΔI. The winding number N and the magnetic cross section A_{fe} are design parameters. If the swing in the flux density ΔB exceeds the saturation flux density B_{sat} of the softmagnetic material, the inductor will saturate and thus the inductance will drop significantly (area 3 in fig. 2c). In a unipolar application the current does not reach negative values. Therefore, the flux density cannot become negative either. However, the inductor would work for a negative current (area 1 in figure 2c). But that area cannot be accessed by the application and remains unused. With a permanent magnet in the magnetic circuit the working point (marked red in fig. 2b) can be shifted significantly by the magnet's flux density B_{mag}. As a theoretical limit the swing ΔB can be doubled. As a result the usable area 2 in the L-I curve (see figure 2d) is increased by the same factor. The green area under the blue curve in figure 1b represents the available magnetic energy, which is even four times higher.

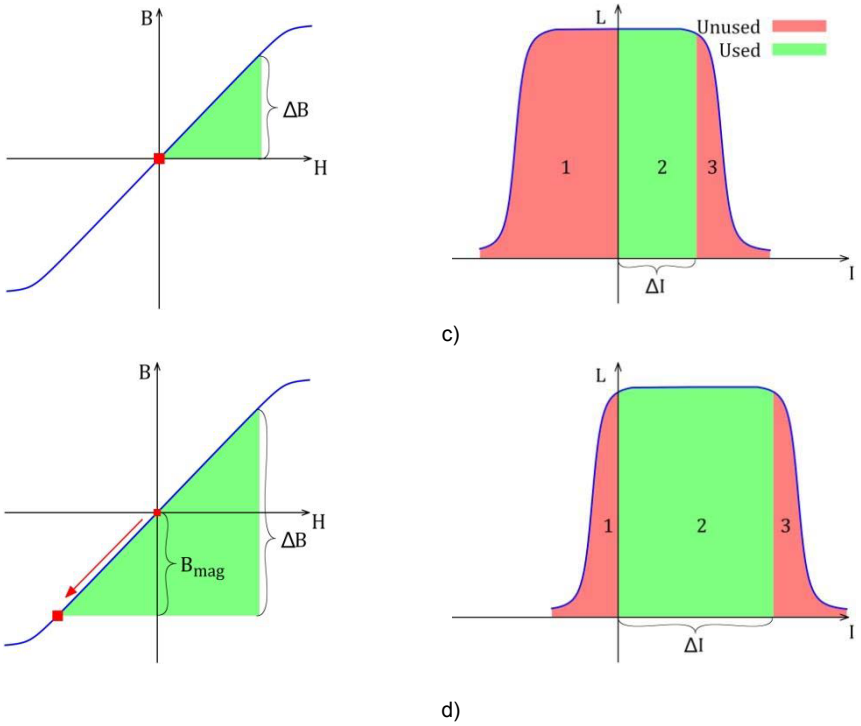

Figure 2: Effect of biasing in B-H curve (a-b), L-I curve (c-d)

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Discussing equation (1), doubling the swing ΔB reveals the following alternatives:

1. Using the same inductor for an application in which the current is bigger up to factor 2 (see change from fig. 2c to 2d).
2. Decreasing N up to factor 2.
3. Decreasing A_{fe} up to factor 2.
4. Increasing L up to factor 2.

Depending on the designing priorities it is possible to combine the alternatives in order to achieve the best inductor for a specific application.

One drawback of the biasing technique might be that depending on the ripple current I_{pp} and frequency the soft-magnetic core losses can increase significantly when using alternative 2 and/or 3. However, in this case alternative 4 can be applied successfully. The inductance can increase up to factor 2 while keeping the inductor's volume the same. Simultaneously the ripple current is decreased by the same factor. To see this effect equation (1) has to be limited to the AC part:

$$(2L)\cdot(I_{pp}/2)=L\cdot I_{pp}=N\cdot B_{pp}\cdot A_{fe} \quad (2)$$

It can be seen that the AC flux density B_{pp} is not increased compared to the conventional choke. A higher inductance means lower switching losses and better EMI behavior.

Practical realization

a) Additional losses

In a biased inductor the permanent magnet is exposed to AC fields. Even for low ripple and frequencies a conventional sintered NdFeB-magnet would produce extraordinary losses due to eddy current causing a local hot spot and an inefficient inductor.

STS has modified a measurement setup for soft-magnetic cores in order to measure AC losses in permanent magnets directly. It was possible to optimize the magnetic material in such a way that these additional losses are orders of magnitude lower even compared to state of the art magnetic materials.

b) Demagnetization due to current

The conventional magnet cannot withstand an opposing field up to the saturation flux density ($B_{sat} \approx 440$mT for a typical high performance ferrite at 100°C). However, there are materials which can withstand such a magnetic stress. In case of overcurrent even this material would reach its limit. STS has found a solution to prevent the magnet from demagnetization at those overcurrents.

c) Thermal aging

In addition to the short-time temperature influence one has to look at the thermal stability during the lifetime cycle. Depending on the specification temperatures of up to 120°C can be reached in the vicinity of the permanent magnet. Long-term measurements over several thousand hours show that the different hard-magnetic materials behave quite differently. STS has chosen a magnet optimized in terms of thermal stability and has additionally performed field tests under full-load condition over several thousand hours.

For ferrite based inductors STS has addressed all problems and the result is a working magnetically biased inductor. The brand MaxFlux was given to this loss-optimized biasing technology. To show what can be achieved the two following examples are discussed. The results are shown in table 1.

Specification I:
L=200µH, I_{DC}=100A, I_{pp}=50A, f=20kHz

The ideal winding technique for this application is copper foil. Following the way of alternative 2 copper is reduced by almost 40 per cent. The core mass is not reduced, since the winding window width does not depend on the number of turns, but on the copper foil width. The additional benefit is a significant reduction of losses. The increased core losses and the additional losses caused by the permanent magnet are considered. If volume and mass are a priority alternative 3 should be selected.

Specification II:
L=640µH, I_{DC}=30A, I_{pp}=27A, f=48kHz

This application has got extreme AC requirements. Therefore, only ferrite is suitable. Biasing the core allows to reduce the number of turns by about 44 per cent. Because litz wire is used the winding window width can be decreased at the same time, too. With the modular URR concept one can make good use of this fact and can save core material by reducing the effective iron path length. The losses are almost the same, because the soft magnetic core losses increase significantly.

Measurement results

At first specification I is discussed.

In figure 3 the inductance behavior in relation to current and frequency is shown. One can see that the demanded full-load inductance value is reached with all designs.
However, the biased chokes are built similar to the design shown in table 1 (see column "Alternative 3") and are therefore much smaller. Figure 3b shows the different AC behavior. With a conventional magnet the resonance is almost completely damped, which is equivalent to high resistive losses. With the optimized magnet one gets excellent results similar to the case of the conventional choke.
For specification II another point of view is shown. In order to demonstrate the biasing effect of the magnet directly two L-I curves are shown in figure 4. The number of turns and core geometry are the same for both chokes. Adding the permanent magnets into the magnetic circuit shifts the L-I curve about 20 amperes to the right, so that specification is fulfilled.
One can see that the optimum of the biasing technique is reached. Using an even stronger permanent magnet would lead to a further shift to the right causing a significant reduction of the inductance in partial load (see also fig. 2d). Thus the ripple current would increase and the converter would become unstable when working at small input current.
All the inductance measurements presented here were performed at 100°C.

	Design comparison (copper foil)				
	Unbiased	Alternative 2		Alternative 3	
Copper mass [kg]	2.01	1.22	-39%	1.63	-19%
Core mass [kg]	5.72	5.72	0%	3.34	-42%
Total mass [kg]	10.00	8.81	-12%	6.87	-31%
Volume [l]	3.00	2.67	-11%	2.21	-26%
Total losses [W]	72.9	54.7	-25%	67.1	-8%

	Design comparison (one layer HF-litz wire)		
	Unbiased	Alternative 2	
Copper mass [kg]	0.86	0.48	-44%
Core mass [kg]	1.73	1.34	-22%
Total mass [kg]	4.60	3.21	-30%
Volume [l]	1.85	1.31	-29%
Total losses [W]	57.5	58.3	1%

Table 1: Comparison between unbiased and biased inductor

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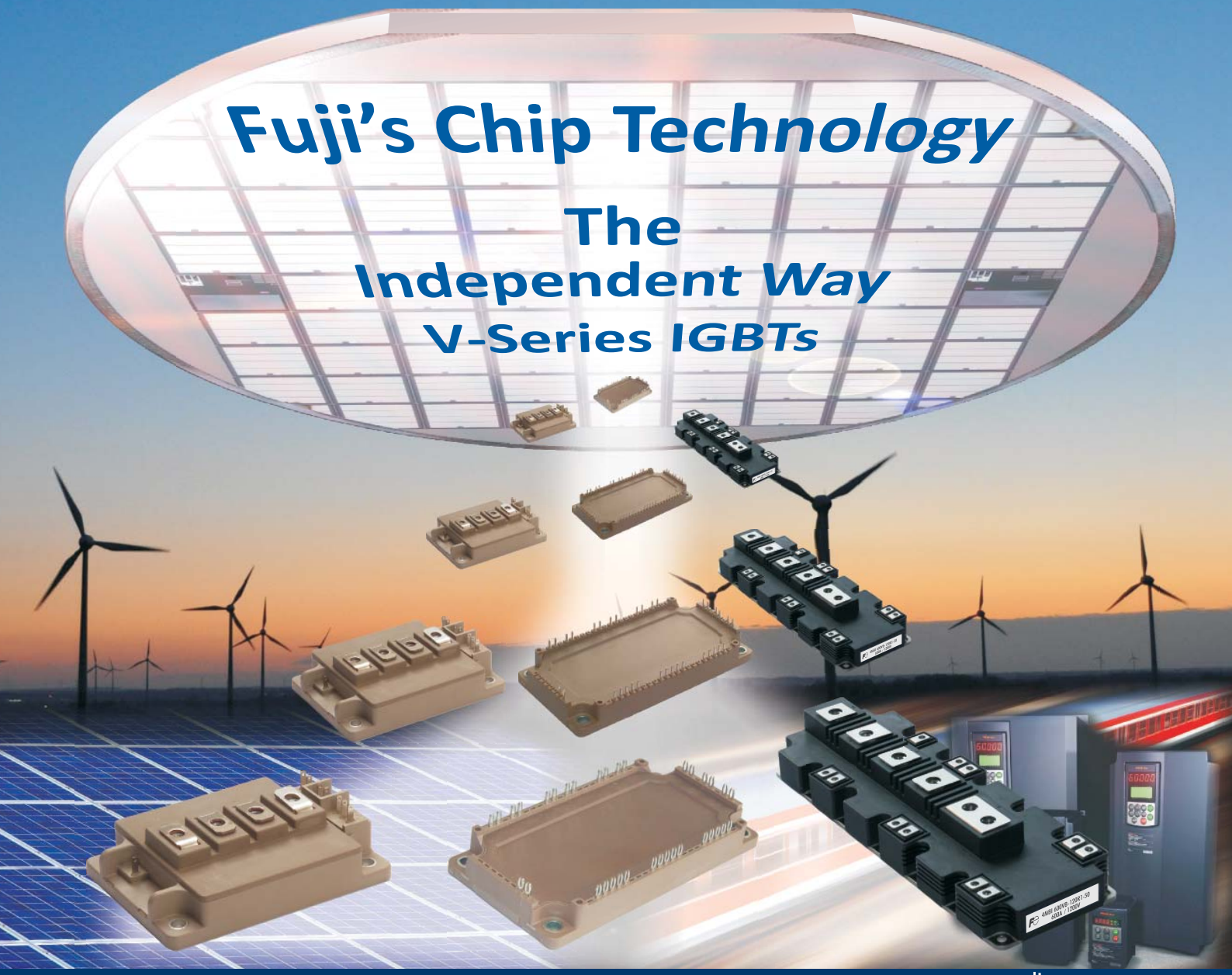

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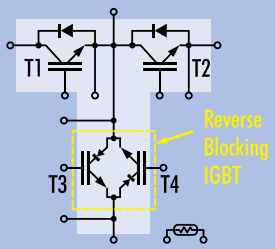
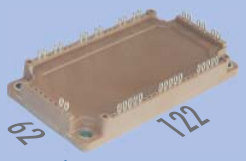


I_C	T1 & T2	T3 & T4
220A	1700V	1200V
300A	1200V	600V
	1200V	900V
340A	1200V	600V
400A	600V	600V
	1200V	600V

With solder pins



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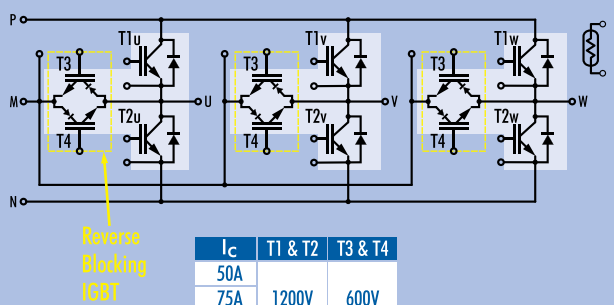
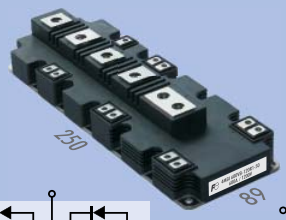
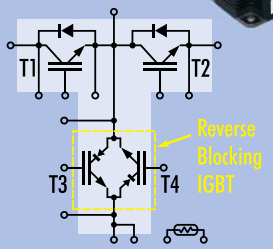
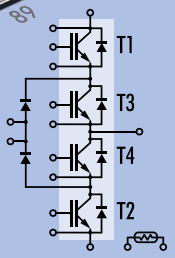


I_C	T1 & T2	T3 & T4
50A	1200V	600V
75A		
100A		





I_C	T1 & T2	T3 & T4
450A	1200V	900V
650A		
900A		
450A	1700V	1200V
600A		



I_C	T1, T2 , T3 , T4
600A	1200V

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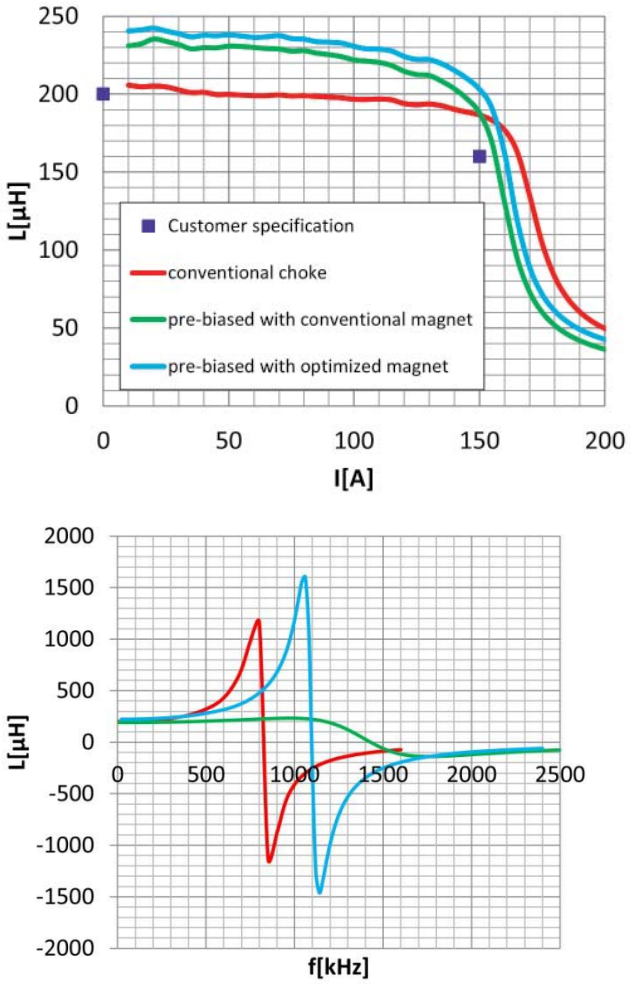


Figure 3: L(I)-curve (a) and L(f)-curve (b) for specification I

Conclusion

In this article a new generation of magnetically biased inductors is presented. When developing this family special care was taken concerning the issue of the additional losses caused by the permanent magnet. As a result one can say that these losses are small compared to copper and core losses and do not prevent designing an efficient biased inductor.

	Conventional	Unbiased InDUR	Biased InDUR
Specification III	L=75µH, I_{DC}=300A, I_{pp}=120A, f=16kHz		
Mass [kg]	26	17	10
Dimension [mm]	272x213x144	239x193x144	170x193x144
Volume [l]	8.3	6.6	4.7
Energy density [J/m³]	410	516	722
Loss density [W/dm³]	19	40	39
Sketch			

Table 2: Comparison for specification III between conventional choke, unbiased InDUR choke and biased InDUR choke (from left to right).

The MaxFlux technology is not limited to certain core geometries and therefore suitable for the whole power range. Biasing the core results in different possibilities to optimize the inductance in a way most suitable for the application under consideration.

Decreasing the inductor's volume leads to a higher energy density. The total losses will not increase, but depending on the ratio of copper and core reduction the loss density will rise. To deal with this an effective cooling is necessary.

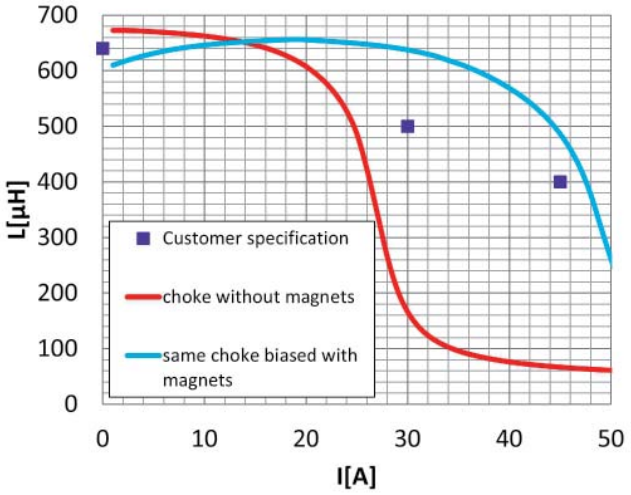


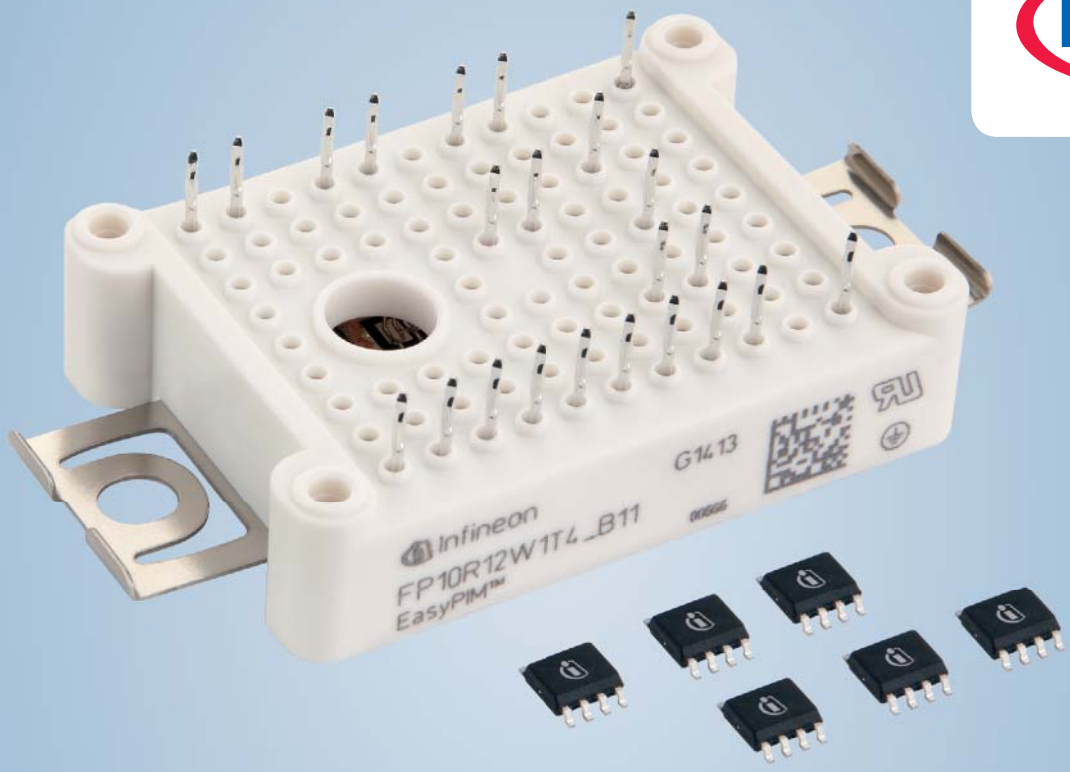
Figure 4: L(I)-curve for specification II

In 2013, STS presented the innovative cooling concept InDUR. Combined with the MaxFlux technology the volume of a conventional ferrite inductor can be reduced significantly. While MaxFlux lifts the inductor saturation limit, the InDUR casing allows for increasing the loss density as well and therefore further increasing the package density.

This article is concluded with an overview what can be realized with respect to the energy density if combining the InDUR housing for forced cooling (here 2m/s air velocity) and MaxFlux:

References

1) J. T. Ludwig, "Inductors biased with permanent magnets," Electrical Engineering, vol. 80, no. 6, 1961.
2) A. Nakamura et al., „A New Reverse-Biased Choke Coil," Proceedings of Power Con 9, 1982.
3) T. Fujiwara and H. Matsumoto, "A new downsized large current choke coil with magnet bias method," in Telecommunications Energy Conference, 2003. INTELEC '03. The 25th International, 2003.
4) R. Wrobel, N. McNeill and P. Mellor, "Design of a high-temperature pre-biased line choke for power electronics applications," in Power Electronics Specialists Conference, 2008. PESC 2008. IEEE, 2008.
5) G. Shane and S. Sudhoff, "Design Paradigm for Permanent-Magnet-Inductor-Based Power Converters," Energy Conversion, IEEE Transactions on, vol. 28, no. 4, pp. 880-893, 2013.
6) H. Husstedt and M. Kaltenbacher, "Detailed analysis of permanent magnets by means of free field measurements," Journal of Applied Physics, vol. 115, no. 17, 2014.



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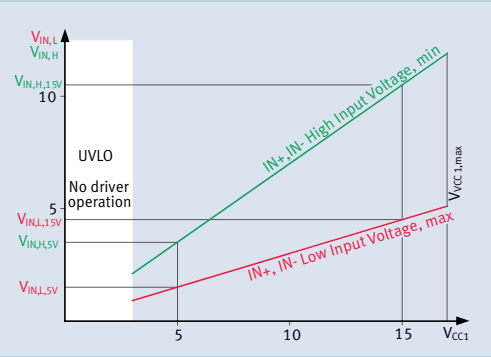

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Easy Conversion

A look at how to implement an analogue-to-digital conversion in a low bandwidth application

By Mark Pallones, Kristine Angelica Sumague and Mike Gomez, Microchip

Implementing an analogue-to-digital conversion in a circuit is one of the most common tasks facing designers and one that can be done in various ways. But for many simple and low bandwidth applications, such as a DC voltmeter for example, the goal is to keep the cost of the implementation low but still obtain a high resolution for the analogue-to-digital conversion.

A simplified schematic of such a circuit is shown in Figure 1. There are two input voltages connected one at a time to op amp U1. Vref is the fixed reference voltage used in calibration and Vmeas is the unknown voltage to be converted. Resistor R1 and capacitor C1 form a charging circuit used to convert input voltage to time. The existence of U1 in the circuit removes the logarithmic characteristic that would occur if the input voltage is directly applied to R1 and C1.

This circuit uses a PIC16F5X microcontroller from Microchip to control the U1 operation by turning the four switches (S1 to S4) on and off. Additionally, the microcontroller measures the time and calculates the digital representation of the unknown input voltage.

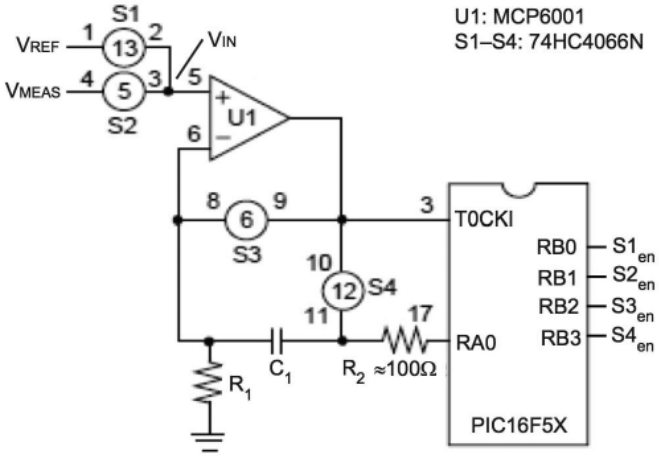

Figure 1: Circuit diagram for an analogue-to-digital circuit

The circuit can also be used as a current mode A-D converter. In this case, the input voltage to the current converter is not needed and the reference current and input current are both routed via analogue switches directly into the capacitor.

The converter requires only five external components and is software and hardware configurable for conversion resolutions from 6 to 10bit, and conversion times of 250µs or longer. The method is usable for both voltage and current conversion and uses a software calibration technique that compensates for time and temperature drift, as well as component errors.

To visualise the different stages of conversion, take a look at the U1 output voltage Vo waveform shown in Figure 2.

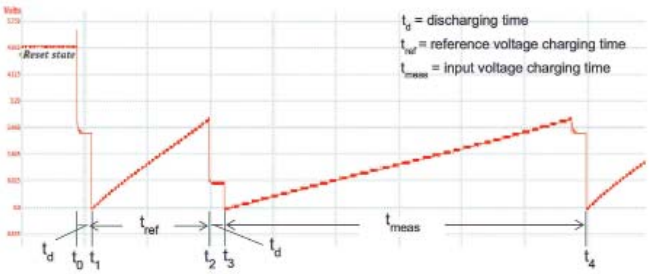

Figure 2: Operational amplifier output voltage waveform

At t0-t1, S1 and S3 are on, S2 and S4 are off and RA0 is pulled to ground by the software. This yields the equivalent circuit in Fig. 3.

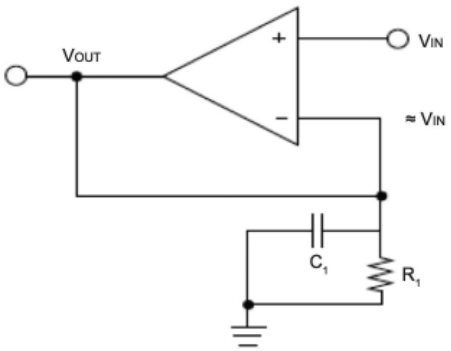

Figure 3: Equivalent circuit during discharging

Vo is equal to Vref since Vin is equal to Vref and S3 to force unity gain feedback. C1 is discharging or is initially discharged after the reset state. In any case, this stage ensures that C1 is fully discharged before going to the next stage. At the end of t1, S1 remains on, S2 remains off, S3 is off, S4 is on and RA0 is configured as an input pin. This yields the equivalent circuit in Figure 4.

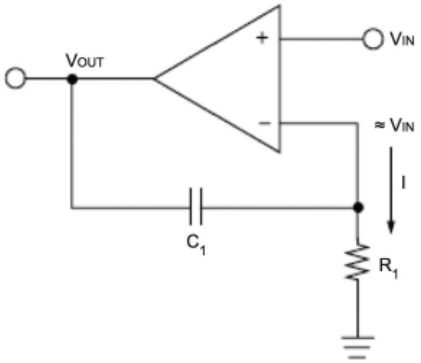

Figure 4: Equivalent circuit during measurement

As a function of Vref, Vo is started to ramp-up linearly while C1 is charging. The Vo ramp-up continues until the threshold voltage input Vth of the microcontroller trips. This generates a software calibration value equal to tref.

This calibration value is measured and used to calibrate out most circuit errors, including inaccuracies in the resistor and capacitor, changes in the Vth, and temperature variation.

After the software calibration value is measured at t2, S2 and S3 are on, S1 and S4 are off and RA0 is pulled to ground again by the software. This yields the same equivalent circuit in Figure 3. However, Vo is equal to Vmeas since Vin is equal to Vmeas and S3 to force unity feedback. C1 is discharging from t2 to t3. At the end of t3, S2 remains on, S1 remains off, S3 is off, S4 is on and RA0 is configured as an input pin. This yields the same equivalent circuit in Figure 4.

As a function of Vmeas, Vo is started to ramp-up linearly while C1 is charging. The Vo ramp-up continues until the Vth of the microcontroller trips. This generates a software Vmeas value equal to tmeas. This value is compared with the software calibration value to determine the actual digital representation of Vmeas.

Circuit equations

Based on the circuit operation, equations are used by the microcontroller to calculate the conversion result. In Figure 4, the current through R1 is equal to the current through C1. When the input voltage Vin is equal to Vref, the relation between the two currents is represented as Equation 1 in Figure 5. When Vin is equal to Vmeas, the relation between the two currents is represented as Equation 2 in Figure 5.

EQUATION 1: R1 AND C1 CURRENT EQUATION WHEN INPUT VOLTAGE IS VREF

$$\frac{V_{ref}}{R1} = C1\frac{dV_0}{dt}$$

EQUATION 2: R1 AND C1 CURRENT EQUATION WHEN INPUT VOLTAGE IS VMEAS

$$\frac{V_{meas}}{R1} = C1\frac{dV_0}{dt}$$

EQUATION 3: INTEGRATION RESULT OF EQUATION 1

$$V_0 = \frac{1}{R1C1}\int_0^{t_{ref}} V_{ref}dt$$

EQUATION 4: INTEGRATION RESULT OF EQUATION 2

$$V_0 = \frac{1}{R1C1}\int_0^{t_{meas}} V_{meas}dt$$

EQUATION 5: U1 VOLTAGE OUTPUT EQUATION AS A FUNCTION OF VREF

$$V_0 = \frac{V_{ref}\,t_{ref}}{R1C1}$$

EQUATION 6: U1 VOLTAGE OUTPUT EQUATION AS A FUNCTION OF VMEAS

$$V_0 = \frac{V_{meas}\,t_{meas}}{R1C1}$$

EQUATION 7: RESULT OF EQUATIONS 5 AND 6

$$\frac{V_{ref}\,t_{ref}}{R1C1} = \frac{V_{meas}\,t_{meas}}{R1C1}$$

EQUATION 8: FINAL CONVERSION

$$V_{meas} = \frac{V_{ref}\,t_{ref}}{t_{meas}}$$

Figure 5: Analogue-to-digital conversion equations

Integrating Equations 1 and 2 yields the results shown in Equations 3 and 4. Since Vref and Vmeas have constant input, Equations 3 and 4 can be further reduced to Equations 5 and 6. At the end of each measurement, Vo of Equations 5 and 6 are both equal to Vth. Therefore, equating both equations yields Equation 7. Here, R1 and C1 can be eliminated and solved for Vmeas, the unknown input voltage.

In Equation 8, it is apparent that the measurement is independent of the value of circuit elements R1 and C1. This makes the conversion insensitive to errors in the R1 and C1 value, due to the inaccuracy or temperature variation. However, this does not mean that the values of R1 and C1 are unimportant in the design of the A-D converter. The values of R1 and C1 should be selected based upon the number of bits of resolution. Looking back at Equation 6 and solving R1C1 you get Equation 9 in Figure 6.

$$R1C1 = \frac{V_{meas}\,t_{meas}}{V_0}$$

where

V_{meas} = Lowest voltage to be measured(at least ten LSBs)

t_{meas} = Time to do the number of bits of resolution desired

$(2^N x1/fosc\ x\ 4\ clock/cycle\ x\ instruction\ cycles\ per\ count.$ Where N is number of bit resolution)

$V_0 = V_{th}$ Threshold Voltage input of the PIC16C5x/PIC16F5x being used (3V estimated)

Figure 6: Calculation of R1C1 value

The actual value for R1C1 should be slightly smaller than calculated to ensure that the PIC16F5X microcontroller does not over count during the measurement. It should be noted that there will be a difference between the R1C1 value when implementing in Assembly and C because the instruction cycles per count when using C are greater than in Assembly.

Circuit performance

In actual applications, if measurement accuracy permits, it may be advantageous to use lower resolution bits and higher clock source. The maths code can be largely reduced and the measure time is reduced by the simpler code and shorter count.

The calibration value removes all first order errors (offset, gain, R and C inaccuracy, power supply voltage and temperature) except the reference voltage drift. Any change in the reference voltage, including noise, may result in measurement errors. Other error sources may be analogue switch leakage, resistor and capacitor non-linearities, input threshold uncertainty and time measurement uncertainty (plus or minus one instruction cycle time). Measured performance shows the converter to be accurate within 1% of full scale.

Conclusion

For a simple and low bandwidth analogue application, it usually requires a low cost yet high resolution A-D converter. By using the PIC16F5X (or the PIC16CFX) baseline family of microcontrollers, this article has demonstrated how to meet such requirements. The A-D converter does not only use fewer components but also has a capability to calibrate out most circuit errors.

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eScooter is Gaining Speed

The life of Swiss postmen in some rural areas may just become a bit easier: In a pilot project they will be equipped with eScooters. Complex power electronics is required to drive the electrically powered two-wheelers and intelligent thermal management ensures reliable operation. This is where HSMtec enters the picture.

Author: Johann Hackl, PM HSMtec, Häusermann, Gars am Kamp, Austria

The main requirement of electrically powered bicycles for postmen is to transport them versatile, speedy and effortless to their destination in the countryside – environmentally friendly and resource conserving. The eScooter's basis is the motor control unit from Rising-edge GmbH (Image 1), and a three-phase permanent magnet synchronous motor with up to 15 kW gives a comfortable driving experience as well as manoeuvrability. The motor controller provides an output current of up to 270 A with 160 A continuously. The computing power necessary for calculating the field-oriented vector control (FOC) is provided by a FPGA. A three-phase full bridge module with six MOSFETs acts as output stage. Since this is a THT module, the motor currents have to flow through the PCB.

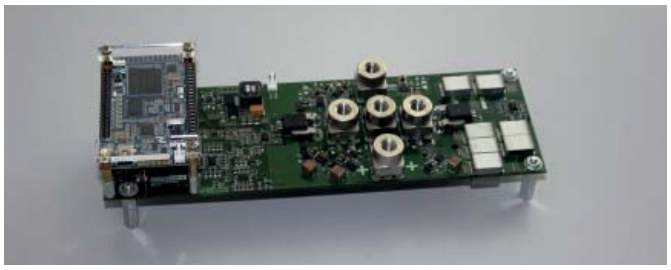

Figure 1: HSMtec makes it possible to integrate the full motor control unit on a single board

Routing high currents of 100 A or more through the PCB requires efficient themal management, a technological challenge for board layout engineers. Power semiconductors for high current and high voltage applications become increasingly complex and create high thermal losses. The excess heat needs to be conveyed away quickly.

Figure 2: The visible copper wires and profiles provide efficient thermal management

However, high currents need broad copper paths which take much space. And space is at a premium on miniaturized boards.

This ongoing miniaturization of control circuits also makes it necessary to integrate sensitive SMT components on the same board as the high current components. This poses various challenges for design engineers. On the one hand, the wire cross sections have to be as large as possible in order to avoid overheating by high currents. At the same time, minimum distances to the sensitive wires of the control circuit are required.

The most common solution places control and power electronics on separate boards using a connector. Placing both functional units on one board would save money and space but this doesn't work with conventional PCB technologies. Using thick copper technology deals with the high currents but not with the fine structures of the control circuits. So we need a PCB technology that allows realizing broad wires for heat transport as well as very fine structures.

Intelligent thermal management with massive copper

HSMtec is a suitable solution for this problem. The PCB technology conforms to DIN EN 60068-2-14 and JEDEC A 101-A and has been audited for aviation and automotive. It works selectively: massive copper is integrated into the board only where high currents actually have to flow through it, as profile or wire. At this point in time, profiles with 500 µm height and widths between 2,0 mm and 12 mm in variable length are available, as well as wires with a diameter of 500 µm (Image 2). Those copper elements are bonded substance-to-substance to the etched conductive patterns using ultrasonic welding. This works in any layer of a FR4-based multilayer. HSMtec allows reducing the heat resulting from high currents quickly to acceptable partial and system temperature. The integrated copper elements can cope with currents up to 400 A.

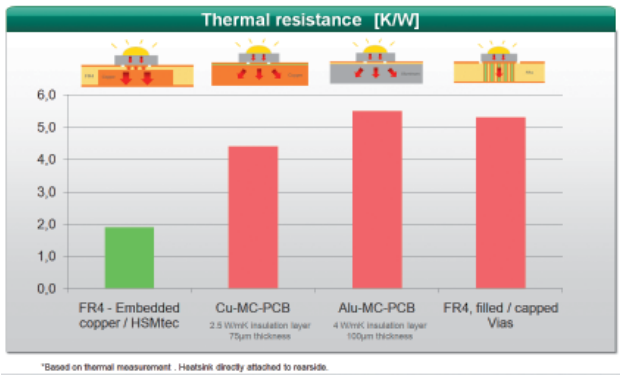

Figure 3: Specific thermal conductivity of different materials

A look at the specific thermal conductivity shows the importance of a continuous metallic path from heat source to heat sink and demon-

strates the potential of HSMtec. The thermal conductivity of copper is a factor 1000 higher than FR4. A thermally optimized layer structure allows for rapid heat spreading and supports the full thermal concept. A real world example: An area of 10 mm x 10 mm can be perforated with more than 400 drill holes with a diameter of 0,25 mm each. The area then consists of 10% copper and its effective thermal conductivity rises to 30 W/m•K. This means that this assembly conducts heat a hundred times better than FR4 and still ten times better than the best heat conducting substrates (Figure 3).

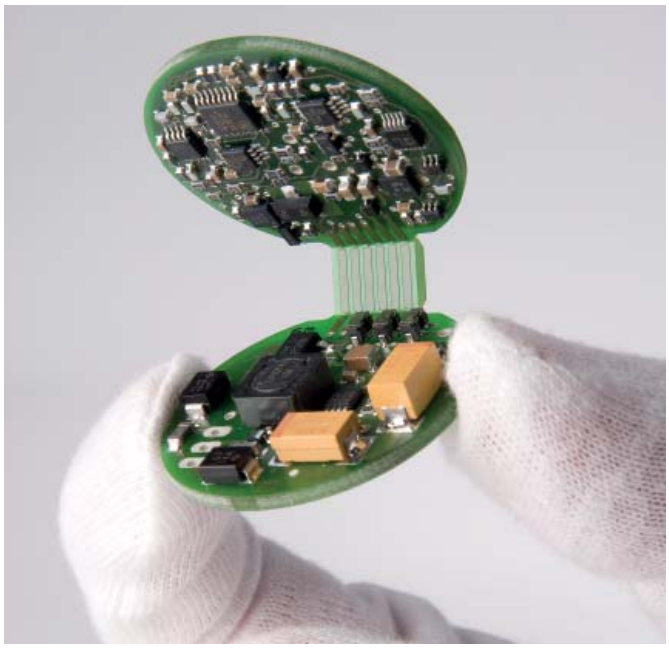

Figure 4: Bending position: Constructing self-supporting multidimensional PCBs with the integrated wires or profiles. Heat and high voltages can be routed through dedicated paths.

HSMtec for reliable eScooters

HSMtec makes it possible to combine large diameters for heat transfer with very fine structures (Figure 4). This solves the problem and provides optimum heat transfer from the power component to the heat sink. So, HSMtec is very suitable for use in the control unit of a DC motor with an IGBT or for electromobility. In this application area, weight and size are of importance, but also the ability to cope with high conductivity in order to dissipate heat rapidly (Figure 5).

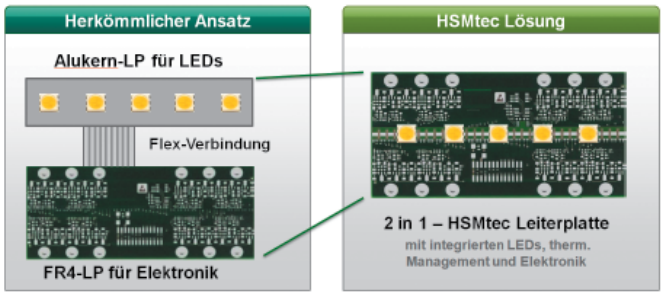

Figure 5: Significant space savings by coexistence of control units and LED on one board Caption: Häusermann

Traditionally, the eScooters motor control required special assemblies in order to route large currents on the PCB. This has changed with HSMtec. This technology makes it possible to integrate the full motor control module on 228 mm x 75 mm on a single board (Figure 6). The massive copper elements in the four-layer board conduct current while dissipating heat rapidly. Since there are neither screwed connections nor cables necessary between module and PCB, this

leads to higher reliability. The motor controller doesn't just regulate the engine but also the recuperation of braking energy. This requires trading-off the mechanical brake power with the rate of recuperation in order to gain as much energy as possible while still executing the right amount of braking force.

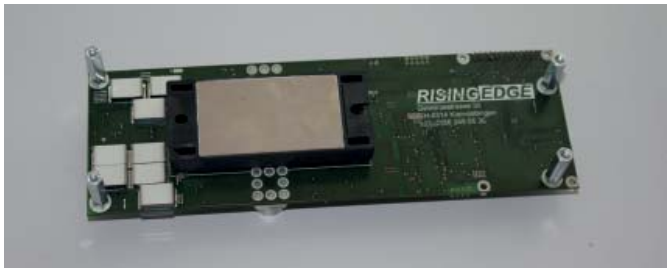

Figure 6: The unpopulated motor control: The first step is the assembly of the output stage, an integrated three-phase full-bridge module with six MOSFETs. Caption: Rising-edge

At the moment, HSMtec is used in prototypes of the eScooter's power-train electronics. Its Small size allows space-saving installation directly on the motor wing. The enormous amount of computing power available through the FPGA may turn the motor controller into a central vehicle computer in the future. It could then provide additional functions like diagnosis and data logging, fleet management using GPS and GSM or diplayand instrument control. The HSMtec board plays a vital part in the development of power and cost efficient DC motor control in restricted space. That means it contributes significantly to future mobility and environment protection.

http://www.haeusermann.at/en

Efficient 3D Modeling Tool for Computation of Inductive Coupling Effects

Nowadays 3D modeling to compute electromagnetic fields is widely disseminated. It is used to evaluate electrical properties of components, assemblies and whole systems. In most cases it is a very time consuming process. Scientists of the Fraunhofer IZM developed a new tool for magnetic coupling computation with an effort reduction of 80% compared to available programs. The graphical geometry input effort could be drastically reduced and the functionality of the tool could be restricted to necessary functions.

By Eckart Hoene, Bernd Stube, Stefan Hoffmann and Bernd Schröder, Fraunhofer IZM

Technological progress in semiconductor switching velocity allows significantly higher switching frequencies and consequently a reduction in cost and size of power electronic devices. However, EMC requirements are rising because of this. The smaller the components for switching, energy storage and cooling become, the higher the percentage especially that of device volume is needed for filtering electromagnetic interferences. In most cases, to meet the limits for conducted noise or electromagnetic fields the generated disturbances need to be filtered. This task is mostly solved with passive components. In practice, EMI filter design is mainly carried out by trial and error in many companies due to the complexity of the topic. For accurate filter performance prediction, besides the nominal values of the components, parasitic properties like equivalent serial resistances ESR and inductances ESL of capacitors have to be considered. Additionally, coupling effects between the passive components gather influence when placed close to each other. Often the filter attenuation is almost exclusively determined by inductive coupling between components with high and low interference levels from frequencies of a few hundred kilohertz.

Over the last few years the group Power Electronics Systems of the Fraunhofer Institute for Reliability and Microintegration (IZM) has successfully solved many of its costumers' EMC issues in which inductive couplings played a key role. Because of its wide experience and available theoretical knowledge the team is often contacted by companies to solve difficult EMC problems. A typical performance requirement of the specialists is the optimization of component placement in EMC filters for power electronic devices to adhere to the limits for conducted noise. A further issue is the detection of critical current paths in hardware designs that affects the functionality. What's more the evaluation of occurring magnetic fields caused by interference currents in cables, inductors and so on in power plants, which have to comply with limits for magnetic fields, are included. The costumers come from varied branches, especially from the automotive sector, railway technology and the renewable energy industry.

The effect of magnetic coupling is illustrated in figure 1 and can be explained with the transformer principle. A current i1 via a conductor 1 (primary side) causes a magnetic flux Φ1 around it. A part of the flux Φ12 penetrates the adjacent conductor 2 (secondary side) and when there is a temporal alteration in this flux a voltage u2 is induced. This physical law can be described with the mutual inductance M and numerically calculated with the Partial Element Equivalent Circuit (PEEC) method.

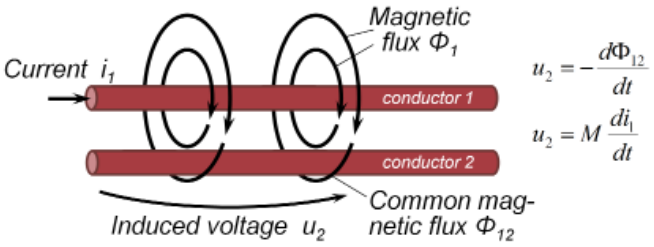

Figure 1: Effect of inductive coupling

What is the current procedure to compute inductive couplings in customer projects? Since there are many different layout tools on the market, customers usually provide their layout to the group in the form of a big pile of papers or files. The central task now is to analyze the specific layout and to detect the EMC relevant current paths. These critical paths can be the source of coupling effects among the component system and strongly influence the EMC performance. To quantify their influence, a combined circuit and field simulation is carried out. The layout of the critical paths including the full 3D dimensions of the components is remodeled. An automatic interface for this work is in our experience not helpful, as manual reworking of the geometry and assigning the crossing nodes is more time consuming than creating a new construction which contains the relevant elements only. This construction is subsequently used as the input file for the PEEC solver Fast Henry to compute and detect coupling effects.

In order to reduce this time-consuming procedure significantly, employees of the institute have developed a new software tool to specify critical EMC paths and to create related input files for the Fast Henry solver more efficiently. The primary idea to reduce the three dimensional geometry input effort is that in PCB layouts the currents mainly flow in the plane of the PCB that is defined as XY plane and therefore the geometry input can be reduced to two dimensions. The third geometry dimension is created by assigning the z coordinate and the height to each segment in a GUI parameter sheet. Due to the rectangular current path structure of many components, for example foil capacitors, current shunts, contactors and fuses, their geometry input

can also be conducted two-dimensionally while employing simple retrospective assignment of the height parameters. The model creation of inductive components can be executed by macros. The symmetrical structure of CM chokes, cylindrical coils and so on are utilized to generate component models with only a few input parameters via a GUI parameter sheet. A further benefit of the software program is that its functionality and handling is focused on the Fast Henry model creation. The geometry philosophy is based on the geometry characterization of the Fast Henry input file syntax.

With this new tool the user can input customer layouts that are given as pdf-files or as pictures (e.g. in jpg-format). A high level of smart functionality is provided for segment creation of critical paths in the PCB plane using the computer mouse. The user interface is based on the modern look and feel of many programs. It is shown in figure 2. The input data is automatically saved into a Fast Henry input file. In addition the Fast Henry solver can be called directly via the tool. Then the calculated data can be processed further by following programs. In this way it can be ascertained very quickly whether a device layout is sufficient to fulfill the EMC requirements.

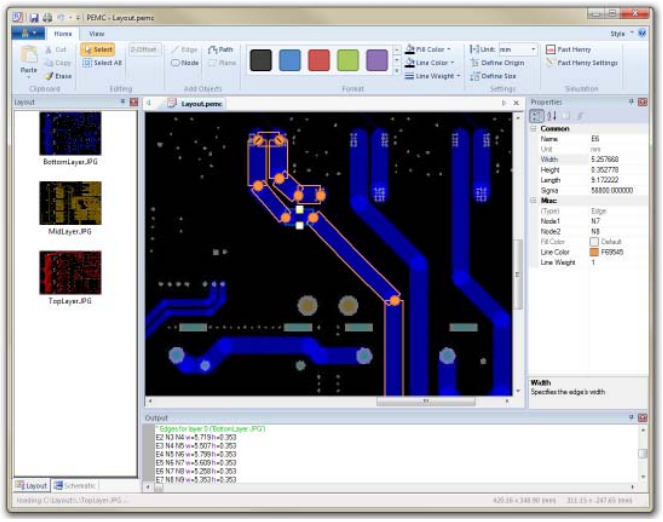

Figure 2: Modern user interface of the software tool

An exemplary illustration of how a DC-DC converter's filter attenuation can be influenced by the component placement is described in the following. In the left picture of figure 3 the filter components are placed adversely and the PCB traces are executed inconveniently. Due to the high magnetic couplings between filter capacitors, coils and PCB traces the conducted noise limits according to CISPR 25 class 5 cannot be adhered to (right graph in figure 3). The influence of inductive couplings on the filter attenuation is dominant at frequencies from 400 kHz.

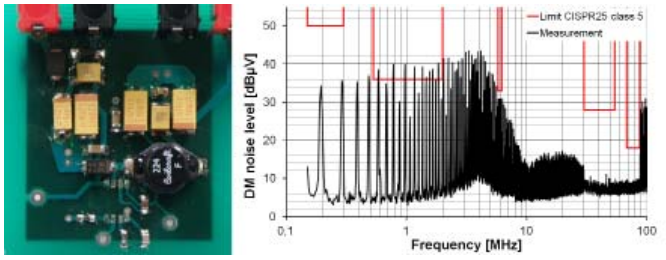

Figure 3: Component placement picture and measurement result of the adverse layout

By favorable adjustment of the component arrangement using identical parts as depicted in figure 4 the DM noise level decreases greatly. It can be seen that the measured interference voltage values lie more than 10dBµV below the limits. Therefore it is possible to decrease the nominal component values. In this way the costs for filter elements can be minimized.

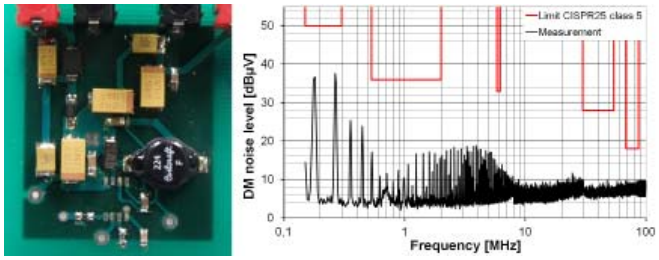

Figure 4 Component placement picture and measurement result of the favorable layout

As is shown in the comparison between the graph in figure 4 and figure 5 the noise level can be predicted with a very high accuracy with the use of simulation. For this purpose the inductive couplings have to be considered. The Fast Henry model to calculate the self and mutual inductances is imaged in the left picture of figure 5. With this methodology the optimal component arrangement can be found before a practical setup is constructed. Consequently unnecessary expensive recursions can be avoided. The developed software tool allows a very fast simulation model creation. Therefore system design costs can be reduced.

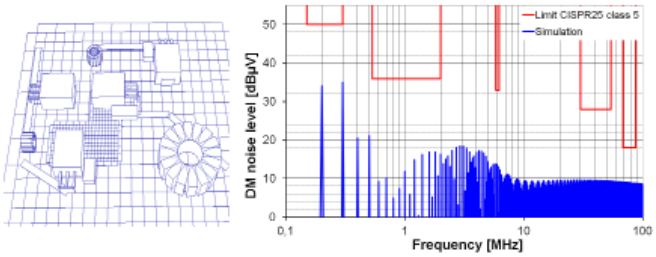

Figure 5 Component placement model and simulation result of the favorable layout

With the aid of the new tool the working group has already successfully solved costumers' EMC problems and the effect is significant. Mainly by restricting the functionality of the tool to necessary functions the effort for modeling is reduced by 80% compared to the tools available on the market.

http://www.izm.fraunhofer.de/

eFPGAsim: A Versatile Motor Drive and Power Electronic Test System

Smart-grid and Electric hybrid-vehicle devices tests and validation made easy with the power of FPGAs

This article presents a versatile test gig for controlled systems and devices such as electric hybrid vehicles (HEV) and smart grid controllers. At the core of this Hardware-In-the-Loop (HIL) test systems are a set of FPGA-based solvers and models that enables the testing of power electronic and motor drive systems with switching frequencies approaching 100 kHz. This HIL system, called eFPGAsim, is designed for fast design iteration process by allowing circuit and parameter modification with a unique FPGA bitstream. The system allows control engineers to validate production controllers in real-time using virtual power systems and motor drives.

By Jean Bélanger, Vincent Lapointe and Christian Dufour;
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The use of FPGA devices for real-time simulation purposes is an emerging trend for the hardware-in-the-loop (HIL) simulation. HIL techniques are used for various applications [1] the main objective of keeping the budget impact at bearable levels during the development phase while running realistic tests in a safe environment on the actual hardware. The computational speed of FPGA, combined with their fast coupling capability with I/Os make them an excellent choice for such applications. In eFPGAsim in particular, special attention is taken to insure that all FPGA-based models exhibit a very low HIL loop latency, sometimes a critical aspect in some high-end motor controller tests.

eFPGAsim description

The RT-LAB real-time simulator is designed to run models on FPGA and CPU. On the CPU, most Simulink models and toolboxes like SimPowerSystems are supported. On the FPGA, a customized suite of models and solvers was designed by OPAL-RT and is called eFPGAsim.

In eFPGAsim, the set of FPGA motor drive models available as of Q2-2014 are:

- FEA-based Permanent Magnet Synchronous Motor (PMSM, IPM) [3]
- Switched Reluctance Motor (SRM) [4]
- Induction motor or induction generator (IM/DFIM)

The various machines model is designed so that all parameters can be modified online. The power electronic part is customizable using a variable topology FPGA solver called Electric Hardware Solver (eHS)[1].

The system is designed for fast design iteration process by allowing circuit and parameter modification with a single bitstream to decrease the time between design iterations to a few seconds. Both eHS and machines are designed using floating-point arithmetic. The system allows control engineers to validate prototype and production controllers in real-time using a virtual drives along with the connected power electronics. The time step of the solver varies from 150 nanoseconds to one microsecond and the total latency between the IGBT firing signals and the voltages and currents outputs at the analog outputs varies between 1 to 1.5 µs.

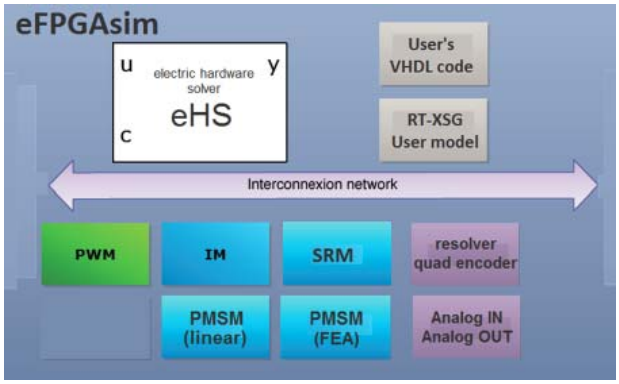


Figure 1: eFPGAsim structure

User can implement himself any type of converter circuits with the eHS FPGA generic solver and the schematic editor of SimPowerSystem, PLECS and PSIM. Simple 2-level inverters, buck, boost, H-bridge and SRM uni-directional converters or more complex power electronic circuits with grid connected converter such a matix converters, 3-level NPC or flying-capacitor topologies can easily be simulated with time step betwen 200 nanoseconds and 1 microsecond. The circuit topology and parameters can be modified on-the-fly in a few seconds without regenerating the FPGA bitstream, which save a lot of time. Several pre-maid circuit example are provided.

The eFPGAsim suite also allows the user to add their own VHDL or Xilinx System Generator code. These models' availability, as well as their connections are customizable on a fixed FPGA bistream that doesn't need to be recompiled. This eFPGAsim structure is depicted in Figure 1

Smart-Grid applications

The modern smart grid is designed to harness all available energy on the grid, not only from the main generating centers but also from the lower-end part of the grid [5]. A typical application of this smart-grid concept is the distribution grid connection of renewable energies such as wind turbines.

The main objective of a wind turbine is to permit the maximum energy capture from the wind for all conditions of the wind and grid. On one part, the mechanical power of a wind turbine that can be extracted greatly depends on wind speed [2][6].

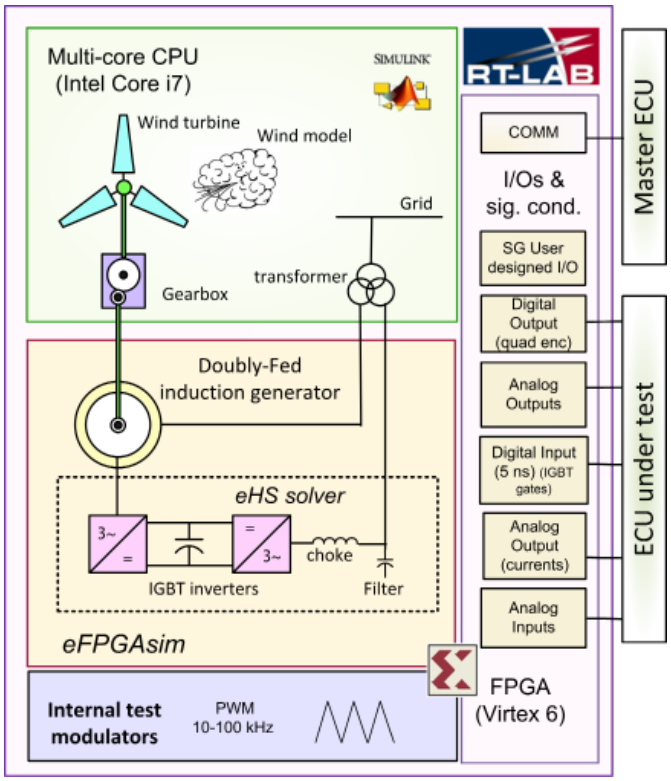


Figure 2: Wind turbine and DFIM modeling on the CPU and FPGA of the RT-LAB simulator.

In the doubly fed induction machine generator, the rotor is coupled to the turbine shaft through a gearbox while the stator is connected directly to the fixed frequency grid. The normalized difference between the stator electrical frequency and the rotor speed is called the induction machine slip and determines, in part, the power balances in the machine.

Other types of control can be used (ex: blade pitch control) to keep energy extraction near its optimal values. Several other benefits can be obtained from the use of variable speed generators for wind turbine and the reader is referred to [2] for further details.

The design and test of such wind turbines controllers is quite complex indeed. Control laws are well-known in theory. This theory is usually made using linear systems. The challenge here is really to predict how well the controller will behave in the presence of saturation effects (ex: feeding transformer) or when the system goes out of specified working mode and goes into contingency mode. In this mode, special protection code is executed (for example to turn-off the inverter gating, or to put the blades into stall mode flowing the detection of dangerous wind levels).

Indeed, the 'device control code' (ex: PID) is typically only 10-20% of the total code of an industry-grade controller. The other 80-90% is used for protection, diagnostics and interfaces. All these parts can be test together carefully using a HIL simulation such as eFPGAsim.

Figure 2 shows the typical model lay-out for a simple DFIM controller test using the eFPGAsim HIL simulator. High frequency power electronic device and the induction motor are located on the FPGA computational engine. Other parts, such as the feeding circuits and the mechanical model of the wind turbines are implanted in the CPU of the HIL.

In Figure 3, we show the outputs at the Analog Outputs (read by the controller under tests) of the HIL when we run the induction machine at 120 Hz fundamental frequency on the stator at 2160 RPM rotor speed (slip=0.1) with short-circuited rotor. The PWM frequency is 1.2 kHz and in the test we change the modulation index from 0.7 to 0.8.

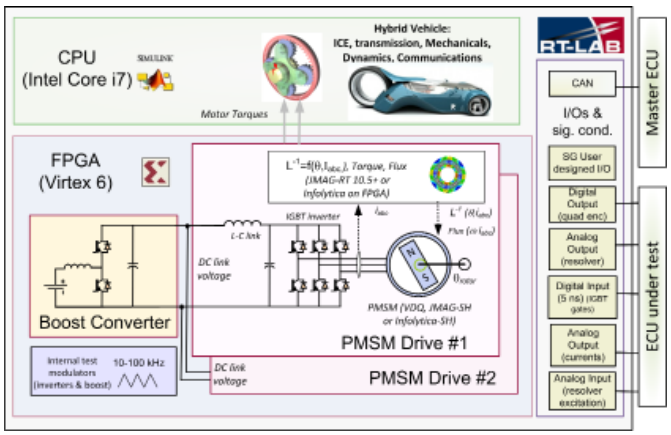


Figure 3 FPGA current captured on oscilloscope for PWM mode @ 2160 rpm

multi-Controller interaction and coordination

In smart-grids, needless to say, many controllers interact with each other and this has to be tested also. This can be done by interconnecting synchronously many such eFPGAsim simulators.

One key aspect of these multi-controller interaction and coordination is the communication layer. Opal-RT simulator supports most power systems communication protocols such as DNP3, IEC60870-5-104, IEC61850-8-1 GOOSE, IEC61850-9-2 Sampled Values, Modbus, C37.118.

Hybrid Electric Vehicle applications

The concept of Virtual Motor Drives (VMD) is increasingly gaining acceptance in the automotive industry. They are used to test and validate complex drives systems found in modern hybrid vehicle drive trains [3]. VMD are also used in many other applications such as high-efficiency air conditioners and machine tools [4] and ship drives [6] among others.

The use of VMD can lead to faster development cycles and improved test coverage. Development cycles are accelerated by the fact that physical drive design and construction can be done in parallel with control development. Control engineers who used to validate their control schemes on the real drive prototype can now use the VMD, which is easy to program and configure. Test coverage can also be improved because the VMD can go to operating points that are not reachable using real devices without damaging them.

Testing of Hybrid Electric Vehicles (HEV) is made using VMD. Recently, car manufacturers have been pushing to use higher accuracy Permanent Magnet Synchronous Motors (PMSM) models rather than the classic Park 2-axis model (So-called DQ or Park model). Finite-Element-Analysis (FEA) PMSM models have recently been used and validated successfully on FPGA [3]. These FEA models include high-resolution effects such as the back-EMF and inductance included slot-effect and the latter also included saturation. This latter model is called the Spatial Harmonic model.

In Figure 4, we show the model lay-out for a typical HEV configuration with two PMSM motors and a boost inverter, usable for testing a Prius-like HEV [3].

Figure 4: eFPGAsim set-up for HEV test

References

[1] C. Dufour, T. Ould Bachir, L.-A, Grégoire, J. Bélanger, "Real-time Simulation of Power Electronic Systems and Devices" Chapter 15 of the book: "Dynamics and control of switched electronic systems: Advanced perspectives for modeling, simulation and control of power converters" Springer series on Advances in Industrial Control, Francesco Vasca and Luigi Iannelli (Eds.), Springer, 2012. ISBN 978-1-4471-2885-4

[2] H. Polinder, S. W.H. de Haan, M. R. Dubois, J. G. Slootweg, "Basic Operation Principles and Electrical Conversion Systems of Wind Turbines", EPE Journal, Vol. 15, no 4, Dec 2005.

[3] Y. Inaba, S. Cense, T. Ould Bachir, H. Yamashita, C. Dufour, "A Dual High-Speed PMSM Motor Drive Emulator with Finite Element Analysis on FPGA chip with Full Fault Testing Capability", Proceedings of the 14th European Conference on Power Electronics and Applications (EPE-2011), Birmingham, England, Aug. 30- Sept. 1, 2011

[4] C. Dufour, S. Cense, J. Bélanger, "FPGA-based Switched Reluctance Motor Drive and DC-DC Converter Models for High-Bandwidth HIL Real-Time Simulator", Proceedings of the 15th European Conference on Power Electronics and Applications (EPE'13 ECCE Europe), Lille, France, Sept. 3-5, 2013

[5] C. Dufour, J. Bélanger "On the Use of Real-Time Simulation Technology in Smart Grid Research and Development", Procedding of the ECCE-2013 IEEE Energy Conversion Congress and Expo, Denver, Colorado, USA, Sept. 15-19, 2013

[6] R. Pena, J.C. Clare, G.M. Asher, "Doubly Fed Induction Generator Using Back-to-Back PWM Converter and its Application to Variable-Speed Wind-Energy Generation", IEE Proc.-Electr. Power Appl., Vol. 143, No. 3, May 1999

http://opal-rt.com/

7th Developer Forum on Rechargeable Battery

For three days the tiny city Aschaffenburg was the capital of the battery world. In recent years, the rechargeable battery developer forum with trade show organised by batteryuniversity.eu has developed into one of the most important European sector meetings for all rechargeable battery manufacturers and their suppliers and customers.

By Marisa Robles Consée, Corresponding Editor; Bodo's Power Systems

The three-day trade event again kicked off with two half-day intensive seminars on the topics of Battery Packs developed properly and Lithium Ion Rechargeable Battery Technologies/Battery Management Systems on 25th March, 2014. Offered for the first time in 2013, each year around 120 participants made use of the opportunity to have their knowledge updated by batteryuniversity.eu experts in just a few hours in the run-up to the developer forum, and once again this year there were a large number of reserved places, as Dr. Jochen Mähliß, head of batteryuniversity.eu, emphasizes: "The overwhelmingly positive resonance to this additional offering reflects the incredible dynamism with which the sector is currently moving forward. Given the rapid technological progress in the area of mobile power supplies and the many standards and regulations, etc. which are sometimes difficult to grasp even for insiders, it is understandably becoming increasingly difficult for companies and their employees to maintain an overview. We are attempting to counteract this with our intensive seminars which save time and costs for participants. We are therefore very pleased that this training offering receives so much interest".

Figure 1: The 7th developer forum on rechargeable battery attracted more than 500 attendees. (Picture: 3W Media)

More than 500 participants attended this year's expert forum, which took place on March 26th and 27th. Around 30 top-class experts informed about the latest trends from research and development. This year, Kurt Sigl, President of the Federal Association for eMobility (BEM) and Dr. Reiner Korthauer, Director of the Trade Association for Transformers and Power Supplies at the Central Electrotechnology and Electronics Industry Association (ZVEI) had been engaged as key speakers; they opened both morning programs with guest lectures on the topics of eMobiliy and Stationary Energy Storage. Further key aspects this year were formed by the presentation of current and coming cell generations, the latest battery packaging methods, innovative charging and safety concepts and also problem-solving approaches for OEMs with regard to rechargeable battery storage, fire warning technology, the REACH regulation and much more. The conference was rounded off by two parallel held sessions on the topics of Electric Mobility and Energy Storage & Security. As the event is getting more and more international, for the first time the expert lectures held in German had been translated simultaneously into English.

The developer forum was accompanied by a trade show with 38 companies that presented their products, solution approaches and services on a total of 2000 m2 of exhibition space again this year. "The combination of lectures and the trade fair has really proven itself in recent years, not least because it means that many contributors are present on both event days and are thus available longer to answer any individual questions forum participants may have. One of the main reasons for the sustained success of this developer forum on rechargeable battery technology is certainly that battery developers and users have a rare chance of a comprehensive expert discussion with lecturers and experts from leading manufacturers and scientific institutions, an opportunity which is made active use of between and after the lectures within the context of the trade fair", states Dr. Mähliß.

Market development

Looking into the future makes Sven Bauer really happy. The CEO of BMZ is convinced that the market is growing continuously and stable. Even more: "If the plans of the German government will become true, there will be a shortage of cells", he predicts. The German Federal Government is looking to have one million electric vehicles on the road by 2020. The aim is to speed up research and development in battery-powered electric vehicles and their market preparation and introduction in Germany. However, the developments not only in

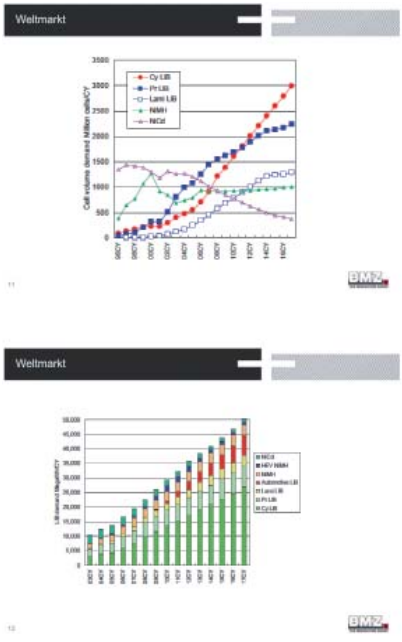


Figure 2: Market

Germany are on a good way. To prepare for the EV market, researchers and battery manufacturers have invested significant resources to develop better battery technologies. At least, the battery will determine the success of the EV, and until improvements are achieved in terms of higher specific energy, longer service life and lower cost, the electric powertrain may be limited to a niche market.

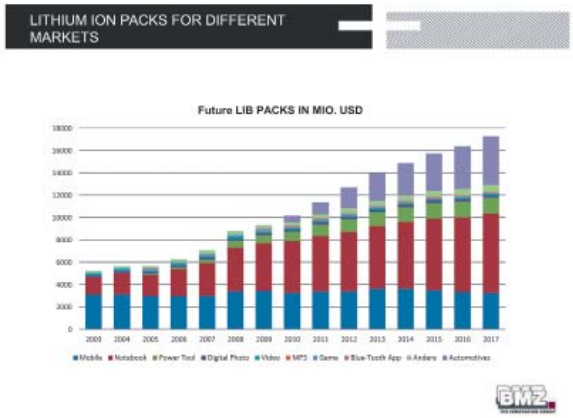


Figure 3: Market

In Germany lithium ion batteries are being utilized more than one hundred million times a day, in cell phones and laptops, in electric toothbrushes, cordless screwdrivers and lawnmowers, pedelecs and countless more applications. The term “Li-ion” has long been a strong argument for buying. However, for competitive reasons it is immensely important for the battery industry to develop even more powerful, even smaller and safer batteries. Sven Bauer expects that the Li-ion cell share will increase about 31% from 2010 (38%) to 2015 (69%). This development will replace NiCd at the mid-low price sector (1.1Ah to 1.3Ah). Despite this, the future Li-ion packs will achieve a growth of almost 18000 Mio. USD in 2017.

But on the same time the battery manufacturers have to face a severe decline of price. Sven Bauer is talking about a price fall of 60% from 2010 to 2020. According to the market researchers Boston Consulting Group (BCG), the largest decrease in battery prices is expected to occur between now and 2020 with more gradual decline thereafter. A battery for the electric powertrain currently costs between 1000 and 1200 USD/kWh. BCG claims that the price of Li-ion will fall to 750 USD/kWh within the next decade. The market researchers point out that the cost of Li-ion can be reduced to 400 USD/kWh in high volume.

eTaxi driver

A new minimalism: Paul Leibhold from Vispiron presented a public transportation network with operational uses as eTaxi, eCarsharing, eTourism and eWheelchair-Taxi. The idea was to offer an EV with zero emissions and very high performance. With 450 kg plus 100 kg battery, the car is really light-weighted. Prof. Peter Neumann took over the design of this innovative vehicle. Important for him was to avoid all unnecessary details of a typical car. With a length of 3.50 m, with seats for driver and two passengers and luggage room for two to four suitcases it may remind more of a rickshaw than of a typical EV. However, the car will have an unlimited range thanks to a manual battery change system. “It is a totally new eTaxi concept”, Paul Leibhold said and continued his explanation: “Weighing only 550 kg it is energy efficient, resourceful and environmentally friendly, providing a lot of driving enjoyment for people and efficient goods transportation in the city.”

Figure 4: The new car concept of Vispiron, presented by Prof. Peter Naumann and Paul Leibold. (Picture: Vispiron)

The project Adaptive City Mobility (ACM) which is founded by the German Federal Ministry for Economic Affairs and Energy (BMWi) with about 6 Mio. Euro is a joint project of Batterie Montage Zentrum (BMZ), Fraunhofer ESK, Roding Automobile, Heinzmann und Vispiron. By 2015, a network for the intelligent City eFleet with multimode user options is scheduled. The real-time data will serve as a base for innovative business models.

http://www.entwicklerforum-akkutechnologien.de

http://www.batteryuniversity.eu/

http://www.ikt-em.de/de/ACM.php

Dual IGBT HVIGBT Module

QID3320004, manufactured by Powerex, Inc. recently attained UL recognition (E78240). This Dual IGBT HVIGBT module makes use of the latest Mitsubishi R-Series chip technology, which offers lower losses, a more rugged SWSOA and RRSOA, and a higher current handling capability as compared to previous generations of chip technology. Highly insulated housings offer enhanced protection by means of greater creepage and strike clearance distance for demanding applications such as medium voltage drives and auxiliary traction.

All components and interconnects are isolated from the heat sinking baseplate, offering simplified system assembly and thermal management.
This device is rated at 200A/3300V.
These modules are designed primarily for medium voltage drive applications.

www.pwrx.com

PIM-Mini 5A to 200A Miniature Pulsed Laser Diode Driver

IXYS Corporation announced the introduction of the compact and lightweight PIM-Mini by its IXYS Colorado division. The PIM-Mini is an air-cooled pulsed current source designed to drive laser diodes, bars, arrays, or any low-impedance load.

Offered in models from 5 amperes to 200 amperes of peak current at up to 48 volts forward voltage, the PIM-Mini has been optimized for OEM designs including industrial, chemical processing and medical applications. Its size and flexibility makes it ideal for research, laboratory, scientific and other applications requiring a compact and economical high-performance pulsed driver.

Pulse widths are adjustable from 25 microseconds to 8,750 microseconds (maximum pulse width varies by model), with a pulse repetition frequency up to 20 hertz. Output current is set with an internal potentiometer or an analog voltage. The pulse width is controlled with the input trigger signal. It requires two DC voltages for operation, 12 volts support power and a compliance voltage equal to 12 volts above the laser diode's forward voltage.

http://www.ixyscolorado.com

Setting the Standard for Hardware-in-The-Loop Testing

Typhoon HIL Inc. continues to deliver cutting edge technologies for Hardware-in-the-Loop testing and real-time simulation for power electronics with new and improved schematic editor, bigger component libraries, faster oscilloscope function, and extended API.

Typhoon HIL Inc. released Typhoon HIL Control Center 2014.1, the newest version of the software suite for its HIL 6-series and HIL 4-series Hardware-in-the-Loop test and real-time simulation systems. With the HIL Control Center 2014 software release, Typhoon HIL integrated the latest technologies into software and firmware while simultaneously streamlining user interface, and significantly shortening Hardware-in-the-Loop setup time for power electronic control systems testing.

The Typhoon HIL Control Center 2014.1 benefits include:

- Faster, easier to use, streamlined Schematic Editor that includes: smart wire routing enabling easier schematic capture, component library explorer tab with easily searchable components.
- New Power Electronics Components in the component library, including: Active Neutral Point Clamped (ANPC) switching block component, RMS measurement components, Controlled sources, new flexible motor operated circuit breaker.
- Improved HIL Control Panel, including: enriched set of run-time control and monitoring options, extended API library, and a scope function optimized for lower memory usage and faster response.

These capabilities are delivered through the Typhoon HIL paradigm for vertically integrated hardware and software improving the user experience and eliminating the need for expensive third party software toolchains. “New Typhoon HIL Control Center Software emphasizes our commitment to ensuring that power electronics engineers work with the superior Hardware-in-the-Loop testing and real-time simulation tools, while enjoying while enjoying a seamless user experience,” said Dr. Dusan Majstorovic, the Director of Product Development at Typhoon HIL Inc. “We know that power electronics engineers are facing tremendous testing challenges and we promise to provide them with the best testing tools that will enable them to push the boundaries of control software/firmware/hardware performance and quality.”

With this release, Typhoon HIL continues to deliver on its commitment to support its customers and incorporate their feedback through the inclusion of features and improvements in the software and firmware. The version of Control Center is available immediately.

Http://Typhoon-HIL.com

3-Phase AC Power Harmonic Filter Capacitors

Cornell Dubilier Electronics, Inc. announces availability of its new PFCH capacitor series for 3-phase AC power harmonic filtering.

Intended for use on the AC output of large inverter system, Type PFCH are designed to filter undesirable harmonics before power is delivered to the grid or load. Typical applications include but are not limited to automatic power factor correction equipment, wind turbine PFC controllers, solar inverter output filters, tuned and detuned capacitor banks and power line conditioning.

Each PFCH capacitor is made with three self healing metallized polypropylene windings, connected in delta, and enclosed in a cylindrical aluminum case filled with environmentally friendly fluid. Built in bleeder resistors reduce voltage to safe levels when capacitors are taken off line for maintenance. To ensure an open and safe failure mode at end of life, type PFCH capacitors utilize a UL810 tested and approved internal mechanical pressure interrupter that disconnects the capacitor winding from the circuit before pressure exceeds unsafe limits.

Type PFCH ratings range from 0.5 KVAR to 17.5 KVAR at 240 Vac, 0.5 to 30 KVAR at 480 Vac, and 1 KVAR to 25 KVAR at 600 Vac. Standard case sizes range from 2.0 inches to 3.5 inches in diameter with lengths ranging from 5.75 inches to 13.73 inches. Larger case sizes and KVAR ratings are available upon request.

For power factor correction applications not requiring higher harmonic filtering, the company offers Type PFCS with greater KVAR ratings needed to achieve unity power factor correction.

In OEM quantities Type PFCH capacitors are available with pricing from $35. Samples are available in 4–6 weeks, production in 8–10 weeks.

For inquiries, contact: Jack Chmura, Phone: (508) 996-8561

www.cde.com

Super Compact Low Frequency Capacitor

CLF3 is a new capacitor built with a new patented concept that continues the tradition of Celem to supply high power capacitors at a very small volume and weight. CLF3 provides power of 1500kVAr in volume of 3 liter and weight of 6 Kg, well below equivalent capacitors in the market.

A major reduction in weight and volume is achieved by using Celem unique design of water cooling electrodes. This design prevents the need of immersing the capacitor in oil, and enables mounting in any angel and position for limited space designs. The CLF3 can even be connected directly to the work-coil from any side of the capacitor.

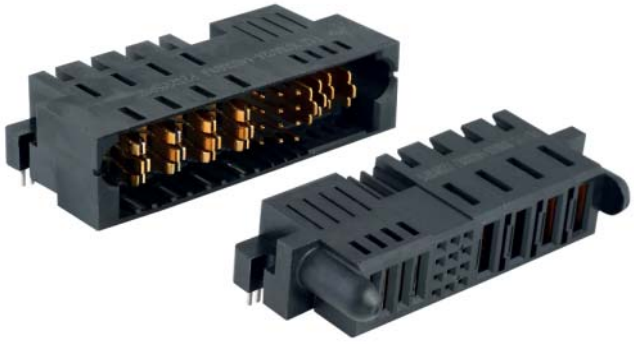
The CLF3 has internally two capacitor elements which can be connected by simple external bridging either in parallel, or in series. Single element can also be connected. This unique structure provides a flexibility of voltage current and capacitance in a single capacitor unit. Celem call this feature ‘smart tapping’.

The CLF3 is built with anodized aluminum electrodes. This makes the capacitor very light in weight and reduces the price of the capacitor. Copper electrodes are available as well.

http://www.celem.com

FCI Completes PwrBlade+™ Joint-Qualifications

FCI, a leading supplier of connectors and interconnect systems, is proud to announce the PwrBlade+™ power connector has completed its long-term reliability tests when cross-mated with the TE Connectivity Multi-Beam XLE connector series. All tests were performed by Contech Research, a leading independent reliability test lab.



PwrBlade+™ is a modular AC/DC power distribution connector designed for demanding PCB and cable mounted applications. The PwrBlade+™ connector builds on the PwrBlade® connector's proven technology, with enhancements to achieve improved current rating performance and reduced power loss. It is rated up to 75A per power contact, without exceeding a 30°C temperature rise in still air. This product features a high power contact and housing design that allows higher current carrying capability in a more compact package. The connector features low power contacts as well as signals for lower power application and monitoring/control circuits.

These products were developed specifically to meet reliability and performance requirements of the telecommunications, datacom, networking, server, storage, network switch, and power supply industries.

www.fci.com

Ultra-Compact 5 Watt USB Power Adapter for European Market

CUI Inc has announced an ultra-compact USB switching power adapter for continental Europe, the EPSA050100UE-I38-EJ.

The 5 W wall plug adapter is among the smallest to integrate USB and has a footprint of just 59 x 42 mm. The small form factor makes it ideally suited for consumer applications, including tablets, media players, e-readers, GPS, and other mobile devices.

The EPSA050100UE-I38-EJ is fully compliant with European ErP phase II regulations and has Level V energy-efficiency compliance for green design requirements.

Additionally, the adapter is equipped with a no-load power draw of less than 0.1 W.

Rated with an output of 5 Vdc at 1 A, the high density EPSA050100UE-I38-EJ operates at ac input voltages ranging from 90~264 Vac. Safety marks include GS, LPS (limited power source), and CE.

The 5 W power adapter meets EN55022 Class B limits for conducted and radiated EMI and provides protections for over-voltage, over current, and short circuit conditions.

The EPSA050100UE-I38-EJ joins CUI's existing North American blade version and is now available through distribution with prices starting at $6.36 for 100 pieces. OEM pricing is available on request.

http://www.cui.com/product/resource/epsa-5w-eu-usb.pdf

Dual Synchronous Low-Voltage Buck Regulator IC

New from Allegro MicroSystems Europe, the A8651 is a dual synchronous low-voltage buck regulator IC that combines flexibility, robustness and automotive (AEC-Q100) qualification for use in multiple output systems with a 2.5 V to 5.5 V system rail.

The device is a dual 2 A, low input voltage synchronous regulator with an adjustable-frequency integrated high-side P-channel MOSFET and a low-side N-channel MOSFET. It incorporates current-mode control to provide simple compensation as well as excellent loop stability.

The A8651 uses external compensation to optimise the transient response without sacrificing stability. It regulates input voltages from 2.5 V to 5.5 V down to output voltages as low as 0.8 V, and is able to supply up to 2 A of load current per regulator.

Key features include an externally adjustable and synchronisable switching frequency, an externally set soft start time to minimise inrush currents, independent “enable” inputs and independent open-drain fault indication outputs with 7.5 ms delay. The “sleep” mode current of the A8651 control circuitry is less than 5 µA.

Protection features include input undervoltage lockout, cycle-by-cycle overcurrent protection, “hiccup” mode short-circuit protection, overvoltage protection and thermal shutdown. In addition, the A8651 provides open-circuit, adjacent pin short-circuit, and short-to-ground protection at every pin to satisfy the most demanding automotive applications.

The A8651 has been designed specifically for use in automotive infotainment, GPS, telecom, networking and home/professional entertainment system applications.

The A8651 device is available in a 20-pin eTSSOP package with exposed thermal pad for enhanced thermal dissipation (suffix LP). It is lead (Pb) free, with 100% matt tin leadframe plating..

www.allegromicro.com

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Company's First 80 Voltage Power Module

Intersil Corporation announced the ISL8216M 80 Volt, 4 Amp non-isolated DC/DC step-down power module. This integrated and simple-to-use module solution marks Intersil's entrance into high voltage infrastructure and industrial applications. The ISL8216M power module provides a complete power supply in a package that can be used across multiple applications from telecom and network infrastructure to factory test equipment with minimal design effort, speeding time to market.

The ISL8216M power module supports a wide input voltage range from 10V up to 80V with an adjustable 2.5V to 30V output range, making it a flexible solution for 12V, 24V, 36V and 48V applications, including high voltage embedded board controllers. Using a single module, designers can optimize the power efficiency of their designs with minimal cost and decreased time to market.

The ISL8216M is a turnkey power module solution that requires only five external components, streamlining power supply design and reducing design and manufacturing risk. The ISL8216M power module is packaged in a rugged thermally enhanced 15mm x 15mm x 3.6mm over-molded High-Density Array (HDA) Package, which permits full load operation without a heat sink or fans, preserving valuable board space. The ISL8216M's full suite of protection features includes over-current, over- / under-voltage and over-temperature shutdown, further enhancing the reliability of power systems.

www.intersil.com/products/ISL8216m

Smart Load Switch Delivering up to 6A Per Channel of Continuous Current

Alpha and Omega Semiconductor Limited (AOS) introduced AOZ1331, the latest addition to the EZPower Smart Load Switch family that delivers up to 6A per channel of continuous current. The dual device's low on-resistance of 20mW in a thermally enhanced 3mm x 2mm DFN package give it an ideal RDS(ON)-to-footprint ratio to enhance performance in space constrained applications. The AOZ1331 is an ideal solution for the latest notebook PCs, Ultrabooks, tablets, set-top-boxes, solid-state drives, networking equipment, LCD TVs, and other consumer electronics applications.

The AOZ1331 includes two n-channel MOSFETs with an input operating voltage range of 0.8V to 5.5V, with an input bias voltage range of 2.5V to 5V. Each load switch operation is independently controlled via a low-voltage logic control signal. The device can switch 6A per channel of continuous current with a turn-on slew rate that can be programmed by an optional external capacitor. Additionally, an internal 220Ω load resistor is integrated into each channel to allow for quick discharging of capacitive output loads.

"The combination of low on-resistance and a thermally enhanced 3x2mm DFN package, allows the AOZ1331 to offer industry-leading performance, making it the ideal load switch for a variety of applications" said Daniel Chang, Vice President of the Power IC Product Line at AOS. "The AOZ1331 simplifies designs by including features such as slew rate control and load discharge that eliminate input supply glitches and other noise.

www.aosmd.com

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Code Composer Studio™ IDE v6 offers a App Center

Consistently delivering the resources to ease software development and reduce accompanying costs, Texas Instruments (TI) (NASDAQ: TXN), introduces the latest version of its Code Composer Studio™ integrated development environment (IDE) – version 6. Based on the latest version of the popular, industry-standard, open-source Eclipse software framework, Code Composer Studio v6 provides numerous updates, features and integrated tools to ease the software development experience. Running on both Windows and Linux® operating systems, Code Composer Studio v6 is available in a number of different license configurations, including several free options, reducing the cost of getting started on an embedded design. Code Composer Studio v6 is compatible across TI's broad embedded processing portfolio including microcontrollers (MCUs), ARM-based processors and digital signal processors (DSPs).

Free licenses of Code Composer Studio are available when using a development board with an integrated debug interface or when using the ultra-low cost XDS100 debug probe (priced at $79). MSP430 users can use a free 16KB code size limited license with the TI compiler or unlimited code size with GCC. The full platinum license for all TI embedded processors is available at the price of $495. Code Composer Studio v6 is also free for Linux and Android application developers who do not require a JTAG debugger.

www.ti.com

60V MOSFETs Featuring Ultra-low Rds(on)

International Rectifier has expanded its StrongIRFET™ MOSFET portfolio to include 60V devices for a wide variety of industrial applications including power tools, Light Electric Vehicle (LEV) inverters, DC motor drives, Li-Ion battery pack protection, and Switched Mode Power Supply (SMPS) secondary-side synchronous rectification.
The new family of 60V StrongIRFET™ power MOSFETs feature ultra-low on-state resistance (Rds(on)) for improved performance in low frequency applications, very high-current carrying capability, soft body diode, and 3V typical threshold voltage to improve noise immunity. Each device in the family is 100% avalanche tested at industry highest avalanche current levels to ensure the most robust solution for demanding industrial applications. The devices are available in through-hole and surface mount D2-PAK packages.
Featuring ultra-low Rds(on) and 100% avalanche tested to demanding industry levels to ensure robustness, IR's family of 60V StrongIRFET™ devices offers a selection of benchmark performance MOSFETs optimized for the industrial market.

http://www.irf.com

Ruggedized Flatpack Capacitors that Handle Vibration up to 50g's

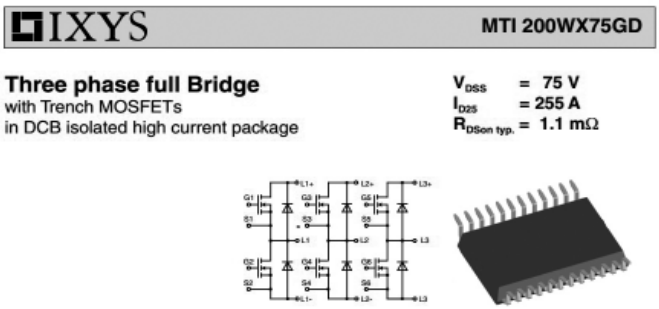
Cornell Dubilier Electronics, Inc. (CDE) announces it has expanded its line of MLS Flatpack aluminum electrolytic capacitors to include a high vibration package, type HVMLS and a high reliability burn-in option, type HRMLS. Applications are mainly for military and commercial flight based power systems that require high energy density, high reliability, rugged capacitors for bulk storage, where relatively expensively wet tantalum capacitors had previously been the only type suited for these environments.
The MLS family of capacitors are packaged in flat, stainless steel cans, one-half inch in height with a near hermetic, precision welded construction, tested up to 80,000 feet. Their

flat form factor allows them to be fit into tight spots, easily cooled, and easily ganged for compact, high bulk storage. The high vibration HVMLS version is further enhanced with ruggedized internal terminations and compressed can edges that keep the internal winding secure when tested up to 50g's of vibration. The high reliability version, type HRMLS are burned-in at rated voltage and 85°C, long recognized as the established military standard to achieve excellent reliability. Both ruggedized and high reliability options may be ordered together by specifying type HVHRMLS to ensure extraordinary life and reliability in the most critical of applications.
The company combines innovative products with engineering expertise to provide reliable solutions for inverters, wind and solar power, electric vehicles, power supplies, medical power, motor drives, HVAC, motors, welding, aerospace, telecom, and UPS systems.

www.cde.com

75V 6-Pack High Power Density Surface Mount DIL Isolated Package

IXYS Corporation announced the availability of MTI200WX75GD with an integrated 6-pack configuration in one isolated surface mountable module (ISOPLUS-DIL).



The MTI200WX75GD offers 3 electrically isolated half bridges with identical layout with a 75V MOSFET featuring an ultra-low on resistance of 1.1 milliohms and real Kelvin gate connections for optimal gate control. The ISOPLUS-DIL package can be surface mounted with standard pick and place equipment, is suitable for re-flow processes and as such can be easily integrated in automated manufacturing lines.
Typical applications, among others, are high efficient DC-DC converters, battery chargers, solar battery chargers, motor inverters, power steering, E-Bikes, light electrical vehicles and pumps.

www.ixys.com

Battery Test Equipment Enables Onsite Testing as Well as Calibration

The ATGF 1500 multifunction battery test equipment for rechargeable batteries and battery chargers, which is tailored to meet the needs of electric bicycle (ebike) specialized dealers, is available from batteryuniversity.eu starting May, 2014.

The easy-to-use ATGF 1500 is suitable for almost all ebike rechargeable battery systems used by the ebike manufacturers Derby Cycle, Gazelle, Simplon and ZEG. After a certified half-day course, users of the ATGF 1500 are able to perform test and maintenance processes - directly onsite in their own workshops - relevant for the safe operation of ebike rechargeable battery systems. The ATGF 1500 enables fast functional testing of rechargeable batteries and battery chargers. In addition, in capacity tests, it can determine the remaining capacity of the rechargeable battery according to the IEC standard and in relation to the number of charge and discharge cycles as well as evaluate its calendar age. Furthermore, if required, a special program of the ATGF 1500 enables a recalibration of the capacity display of the rechargeable battery. After test completion, a test protocol is created, which contains the previously requested customer and dealer addresses, all information about the tested rechargeable battery or battery charger as well as the test result.
With the comprehensive test, maintenance, and calibration options of the ATGF 1500, an important part of the rechargeable battery competence is transferred to the ebike dealer. Being able to immediately and reliably analysis possible sources of error onsite, therefore, contributes significantly to customer satisfaction and customer loyalty.

www.batteryuniversity.eu

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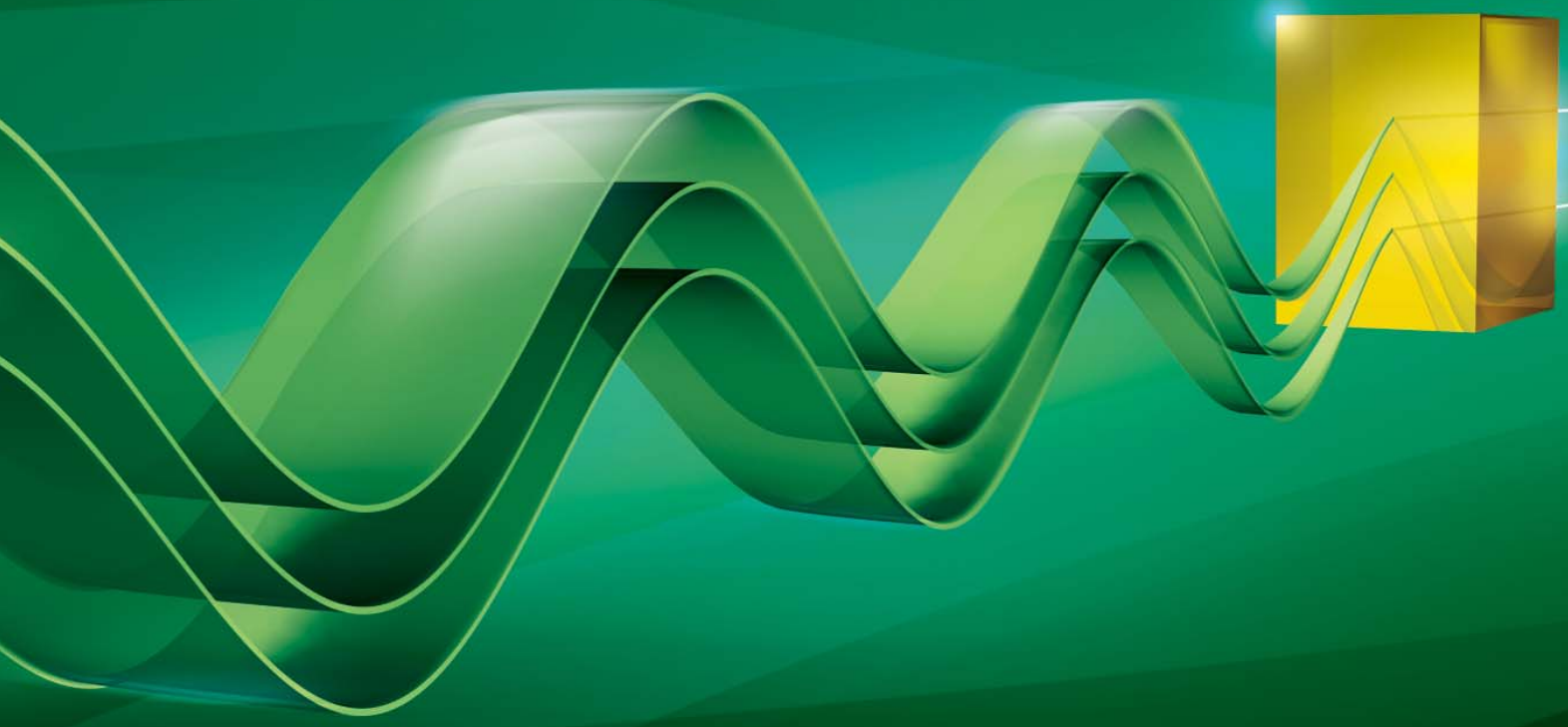

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2U XR Series Product Line Expands to 10 kW and 600 Adc

Magna-Power Electronics, a leader in high-power programmable DC power supplies, expanded it 2U (3.5“ height) rack-mount XR Series product line to 10,000 watts output power, which includes 17 new models spanning voltages up to 1000 Vdc and currents up to 600 Adc. The XR Series addresses requirements in a wide range of applications, including: automated test equipment (ATE), automotive and hybrid/electric development, semi-conductor burn-in, battery charging, among a wide variety of research and development activities. With thousands of units in the field, the XR Series robustness and ease of programmability have been validated at customer sites around the world since its initial release in 2009.

The new 10 kW 2U models continues Magna-Power’s drive for rack-mount programmable DC power density as exemplified through the company’s immensely successful 1.5 kW to 4 kW 1U SL Series and 5 kW to 15 kW 3U TS Series. The new 600 Adc 2U models allow even high current applications to leverage the company‘s high power density products. All Magna-Power programmable DC power supplies feature the company’s current-fed power processing topology for greater tolerance to abusive loads.

XR Series models come standard with monitoring and control from a variety of sources, including: front panel, computer interface and an isolated DB37 analog-digital I/O connector. A Standard Commands for Programmable Instrumentation (SCPI) command set is supported, allowing easy ASCII text programming over a computer interface. In addition, an IVI driver is included for the Visual Studio programming environment along with a dedicated National Instruments LabVIEW™ and LabWindows™ driver. Additional computer interface options include LXI TCP/IP Ethernet (+LXI), IEEE-488 GPIB (+GPIB), USB and RS-485.

The XR Series now spans 70 models from 2 kW to 10 kW output power, 0-5 Vdc to 0-10,000 Vdc output voltage and 0-0.2 Adc to 0-600 Adc output current, making it among the most broadest 2U rack-mount programmable power supply line in the industry. Load-dependent variable speed fans are standard on all models. A High Slew Rate Output (+HS) is available for fast output transitions and higher programming bandwidth. Master-slave operation will be available with the UID47 device, enabling multiple units to be tied in series or parallel.

Production time for new units is 2 weeks for nearly all XR Series models, leveraging Magna-Power’s vertically integrated United States manufacturing facility. For faster delivery, Magna-Power now offers stock models, with a real-time inventory listing on its website.

www.magna-power.com

Pb-Free Solder Paste Provides Lowest Voiding Levels for Large Ground Planes

Indium Corporation's Indium10.1 Solder Paste is a Pb-free halogen-containing solder paste with the lowest levels of voiding for QFNs, BGAs, and pads with large ground planes.

The oxidation-inhibiting properties of Indium10.1 promote industry-leading head-in-pillow and graping resistance, with complete co-alescence, even after long reflow profiles. The exceptional soldering ability of Indium10.1 makes it the best solution for components with less-than-ideal solderability and challenging RF shield metallizations. Indium10.1 enables the lowest cost of ownership to PCB assembly manufacturers through an all-around balanced performance in both high print and soldering yields. It boasts a versatile, well-balanced set of properties with best-in-class printing and soldering performance. Indium10.1 provides industry-leading print definition and transfer efficiency, low voiding performance, and head-in-pillow and graping resistance.

Indium10.1 Solder Paste is part of Indium Corporation's family of high performance, lead-free solder pastes. The series was designed to provide multi-faceted performance characteristics, bringing the right balance of solder paste attributes tailored specifically to each specific manufacturing process. Each paste in the series was developed to optimize print performance and mitigate common defects faced by manufacturers of personal electronics, such as QFN voiding, head-in-pillow, and graping.

For more information about Indium10.1 or the Pb-free Solder Paste series, visit www.indium.com/solder-paste-and-powders/leading-pb-free-solder-pastes/

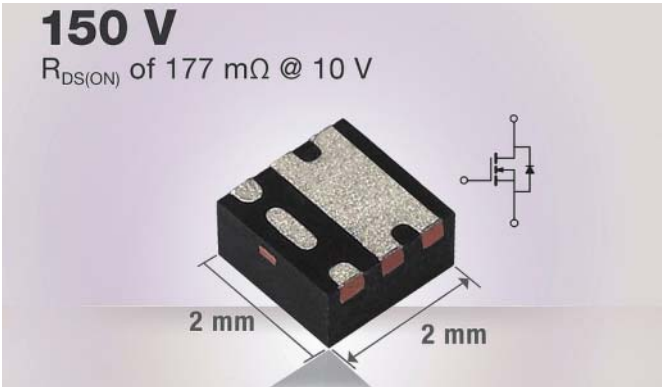
www.indium.com

150 V N-Channel MOSFET in Thermally Enhanced PowerPAK® SC-70 Package

Vishay Intertechnology, Inc. introduced the industry's first 150 V n-channel MOSFET in the compact, thermally enhanced PowerPAK® SC-70 package. Offering the industry's lowest on-resistance at 10 V in the 2 mm by 2 mm footprint area, the Vishay Siliconix SiA446DJ is designed to increase efficiency by reducing conduction and switching losses in a wide range of space-constrained applications.

The SiA446DJ is optimized for primary-side switching in isolated DC/DC converters, boost converters in LED backlighting, and synchronous rectification and load switching for power management applications in Power over Ethernet (PoE) PD switches, telecom DC/DC bricks, and portable electronic devices. For these applications, the PowerPAK SC-70 is 55 % smaller than the 3 mm by 2.8 mm TSOP-6 package while offering 40 % lower thermal resistance.

Built on ThunderFET® technology, the SiA446DJ offers low maximum on-resistance of 177 mΩ at 10 V, 185 mΩ at 7.5 V, and 250 mΩ at 6 V. At 10 V, the device's on-resistance is 53 % lower than the previous-generation device in the TSOP-6 package, while its typical on-resistance times gate charge figure of merit at 10 V is 54 % lower for improved efficiency. Furthermore, the SiA446DJ offers 26 % lower on-resistance than the latest competing device in the 3 mm by 2.7 mm SOT-23 package.



Extending Vishay's portfolio of medium-voltage MOSFETs in compact, thermally enhanced packages, the SiA446DJ joins the previously released 100 V SiA416DJ in the PowerPAK SC-70 and the 100 V SiB456DK in the PowerPAK SC-75. The device is RoHS-compliant, halogen-free, and 100 % RG- and UIS-tested.

www.vishay.com/ppg?62925

www.vishay.com/mosfets/medium-voltage/

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HiPak. Hot applications require innovative solutions.

Flicker from steel smelters is compensated with multi-level voltage source SVC (Static VAR compensation) taking advantage of ABB's innovative HiPak IGBT modules, eg the new 3,300 volt 500 ampere dual module.
Demanding high-power applications such as traction inverters, medium voltage drives, wind turbines, HVDC and FACTS benefit from the high reliability of ABB's HiPak modules.
ABB's family of HiPak modules are available from 1,700 to 6,500 volt as single IGBT, dual / phase-leg IGBT, chopper and dual diodes. All modules feature low losses combined with soft-switching performance and record-breaking Safe Operating Area (SOA).
For more information please contact us or visit our website:
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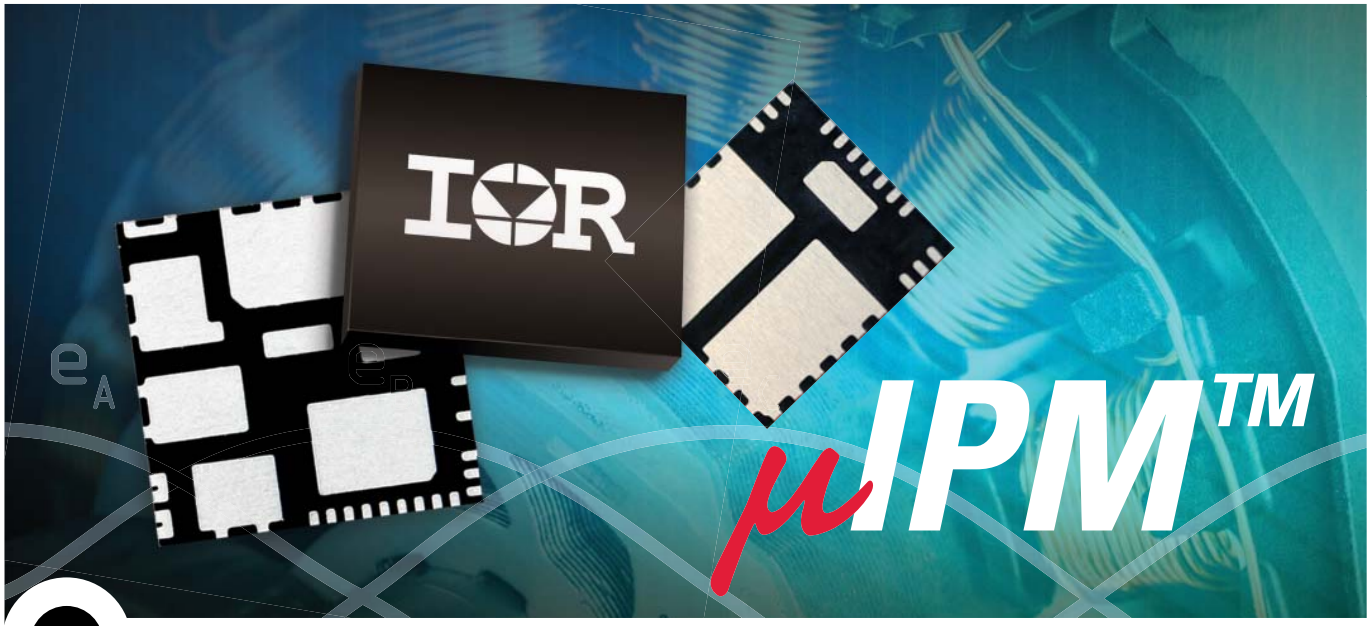

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IRSM836-024MA	12x12	250V	2A	470mA	550mA	60W/72W	3P Open Source
IRSM836-044MA	12x12	250V	4A	750mA	850mA	95W/110W	3P Open Source
IRSM836-025MA	12x12	500V	2A	360mA	440mA	93W/114W	3P Open Source
IRSM836-035MB	12x12	500V	3A	420mA	510mA	108W/135W	3P Common Source
IRSM836-035MA	12x12	500V	3A	420mA	510mA	100W/130W	3P Open Source
IRSM836-045MA	12x12	500V	4A	550mA	750mA	145W/195W	3P Open Source
IRSM808-105MH	8x9	500V	10A	1.1A	1.3A	285W/390W	Half-Bridge
IRSM807-105MH	8x9	500V	10A	1.1A	1.3A	285W/390W	Half-Bridge

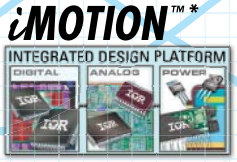
Features:

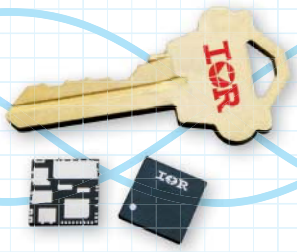
- Integrated Gate Driver IC
- Compact PQFN package offers up to 60% smaller footprint
- Eliminates the need for heat sink
- DC current ratings from 2A to 10A
- Voltage range of 250V – 500V

***μIPM*™ Advantages:**

- Shortens design time
- Shrinks board space requirements
- Simplicity - Eliminates Heat Sink
- Replaces more than 20 discrete parts to deliver a complete motor drive stage
- Slashes assembly time and cost
- Simplifies procurement and inventory management
- Reference design kits available for quick evaluation on any 3-phase motor

*i*MOTION™ *





For more information call +49 (0) 6102 884 311

or visit us at www.irf.com

International IOR Rectifier
THE POWER MANAGEMENT LEADER

* IR's iMOTION™ (ai mo shan), representing the intelligent motion control, is a trademark of International Rectifier
** RMS, Fc=16kHz, 2-phase PWM, ΔTCA=70°C, TA ≈ 25°C